SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

MARCH 1901.

GENERAL PHYSICS.

478. *Density of Solid and Liquid Carbon Dioxide.* **U. Behn.** (Ann. d. Physik, 3. 4. pp. 733–743, Dec., 1900.)—For the density of solid carbon dioxide at — 79° and under a pressure of 1 atmosphere the author gives the mean value 1·53, the extreme limits of the six numbers obtained being 1·512 and 1·548. The apparatus employed consists of a vacuum-jacketed graduated tube, which is about half filled with ether, the latter then being saturated with carbon dioxide and cooled somewhat below — 79°. After the volume and weight of the ether have been determined, solid carbon dioxide is introduced in such quantities that it is just covered by the ether, and the increase in weight and volume of the ether then measured. Using the same apparatus, control experiments with various salts and their saturated solutions gave good results. For measuring the density of the liquid the method employed consists in passing the compressed gas from a steel cylinder first through a tube containing cotton-wool plugs and then into a glass tube in which it condenses and which contains glass floats of varying densities; this tube is surrounded by a vacuum-jacketed vessel containing alcohol, which is cooled to the desired temperature by means of solid carbon dioxide and is kept well stirred. The numbers obtained are contained in the following table, which gives the density of the liquid carbon dioxide under the pressure of its saturated vapour :—

Temperature.	Density.	Difference for 1°.
+ 30°	(0·598)	(0·0470)
+ 20	0·772	(0·0108)
+ 10	0·860	0·00735
0	0·925	0·00602
— 10	0·981	0·00525
— 20	1·031	0·00468
— 30	1·075	0·00422
— 40	1·116	0·00392
— 50	1·154	0·00374
— 60	1·191	0·00367

The numbers in brackets are taken from the results of Amagat, given in the Comptes Rendus, 114. p. 1093 (1892), which agree well with the author's measurements. The values given in the third column of the table, representing the diminution in density caused by a rise of temperature of 1°, show that at the freezing-point this diminution has about the same value as for the gas; as the temperature rises its value increases, at first slowly, but with increasing speed as the critical temperature is approached when it becomes infinite. T. H. P.

479. *Expansion of Water.* **M. Thiesen, K. Scheel,** and **H. Diesselhorst.** (From Wissensch. Abhandl. d. Phys.-Techn. Reichsanstalt, 3. pp. 1–70; summary by Dr. Scheel in Zeitschr. Instrumentenk. 20. pp. 345–347, Dec., 1900.)—Determination of expansion by a method based on communicating columns. Precautions, apparatus, &c., are described. At temperature t° C. the density of water is found to be—

$$1{\cdot}00-\left(\frac{(t-3{\cdot}98)^2}{503570}\cdot\frac{t+283}{t+67{\cdot}26}\right).$$

A. D.

480. *Surface-tensions of Liquids and Melted Metals.* **L. Grunmach.** (Ann. d. Physik, 3. 4. pp. 660–671, Dec., 1900.)—The author describes the method he has employed, viz., that of "capillary ripples." For details reference must be made to the original paper. The following table, in which the numbers denote the surface-tensions in grammes per centimetre at 20° C., gives the results obtained with pure liquids:—

	Method of Ripples.	Method of Capillary Elevation.
Mercury	0·400	—
Water	0·075	0·074
Ethyl Alcohol	0·027	0·029

The numbers given in the second column were obtained by the "Normal Aichungs-Commission." [See also Abstracts Nos. 1315 (1899) and 17 (1901).]
F. G. D.

481. *Mechanical Action of Sprengel Pump.* **H. Boas.** (Deutsch. Phys. Gesell., Verh. 2. 17. pp. 246–248, 1900.)—When a Sprengel pump is used to exhaust a vessel the mercury columns in the fall tubes are seen at first to be broken by short columns of air, but as the exhaustion proceeds these air columns become shorter and shorter until they finally disappear. The exhaustion still progresses, however, and in the present paper the author shows that the mechanical action of the pump at these very low pressures is similar to its visible mechanical action at the higher pressures. By instantaneous illumination of the fall tubes by means of an electric spark the mercury column is seen still to be broken by layers of air filling the whole section of the tube, but owing to the high velocity of the mercury and the thinness of the layers the appearance presented to the eye with ordinary illumination is that of a continuous column. An instantaneous photograph of the columns of a six-fall Sprengel pump is given in the paper. J. B. H.

482. *Graphical Representation of Mean Square Values.* **E. Brisse.** (Écl. Électr. 25. pp. 488–492, Dec. 29, 1900.)—If V denote the effective value of an alternating periodic function e whose period is T, then by definition—

$$V^2.T=\int_t^{t+T} e^2 dt$$

Now if we suppose the curve e drawn in a plane and from every point of the curve we draw lines perpendicular to the plane whose lengths are equal to the ordinates at the points, then if from the extremities of these lines we draw perpendiculars on the axis of t we get a wedge-shaped prismatic solid whose volume is half the value of the above integral. This construction in some cases gives us an easy method of finding effective values. For example, it can be seen graphically that if we have—

$$v_1 = a + e$$

where a is a constant, then—

$$V_1^2 = a^2 + V^2$$

where V_1 is the effective value of v_1. A theorem is given which enables the effective value to be at once found when the wave is a symmetrical trapezium, a triangle and a square being limiting cases of this trapezium. A. R.

483. *Wöhler's Laws.* **J. Gilchrist.** (Engineer, 90. pp. 203–204, Aug. 31, 1900.)—The author discusses some of Wöhler's experiments, and is of opinion that the fracture was caused by the statical breaking limit being exceeded at one point only, from which rupture once started would spread at first rapidly and afterwards more slowly, and that the raising of stress at the point where fracture begins is due to an irregularity or flaw in the bar. That the same cause would not operate in the ordinary breaking of the same bar in a testing machine he attributes to the fact that the greater speed of loading in the Wöhler machine causes the bar to behave in a harder manner. H. R. C.

484. *Motions of the Ether.* **W. Wien.** (Phys. Zeitschr. 2. pp. 148–150, Dec. 8, 1900.)—Wien makes two principal objections to Mie's work on this subject. Firstly, Mie maintains that Helmholtz's hypothesis of an inertia-less ether is inconsistent with the fact that Poynting's Vector possesses vortices. Wien contends that although Helmholtz's hypothesis leads to difficulties, it is not because of the existence of these vortices. Writing P, Q, R for the components of Poynting's Vector, and ξ, η, ζ for $\frac{dQ}{dz} - \frac{dR}{dy}$, &c., Wien deduces equations showing that when ξ, η, ζ are everywhere zero, $\frac{d\xi}{dt}$, $\frac{d\eta}{dt}$, and $\frac{d\zeta}{dt}$ are all zero; and therefore ξ, η, ζ, if ever simultaneously zero at all points in space, must ever remain so. Nevertheless, in general ξ, η, ζ do not simultaneously vanish at all points, though Wien shows we can imagine a system in which that is the case.

Wien next considers Mie's conclusion that certain experiments necessarily lead us to expect that currents exist in the ether. Wien contends, and gives a special example to prove, that a system may exist in which the electric and magnetic forces may be at right angles to each other, but in which Poynting's Vector has no vortices, and therefore in general no ether current is necessary. S. H. B.

485. *Motions of the Ether.* **G. Mie.** (Phys. Zeitschr. 2. pp. 181–182, Dec. 22, 1900.)—This paper is a reply to Wien's remarks [see preceding Abstract]. With regard to the first objection the author understands Wien's meaning to be that examples should have been given of the Poynting Vector possessing vortices changing with the time. Such examples, says the author, giving an instance, are easily constructed, but were omitted from his work for the sake of brevity.

He considers further that there must be some misunderstanding between himself and Wien as to the import of his (Mie's) integrals of the equations of motion for the ether. These Wien asserts to be merely possible integrals. Mie maintains that they are the only possible integrals consistent with all Helmholtz's assumptions.

Finally he regards it as an admitted theorem that in a statical field Poynting's Vector must possess vortices, and maintains that the special example which Wien gives to the contrary fails to disprove it, because in that example vortices must occur at the bounding surface of the field.

S. H. B.

486. *Law of Action of the Internal Forces of a Body.* **H. Petrini.** (Ann. d. Physik, 3. 4. pp. 749–752, Dec., 1900.)—The writer here investigates the conditions that the force between two neighbouring elements of a continuous homogeneous substance shall never become infinite. He assumes the potential of mutual action of the elements to be $dTdT'\phi(r)$, where dT and dT' represent the elements, and r their distance apart. As the result of the mathematical investigation, he obtains the condition required in the form that $\int_0^a r^2\phi(r)dr$ must be finite for any positive value of a.

It is necessary to assume (1) that if β be any numerical quantity greater than unity, then, in the limit, when $r=0$, $\frac{\phi(\beta r)}{\phi(r)}$ is positive. The writer also does assume, though not, as he says, of necessity, (2) that if $r' > r$, then $r'^2\phi(r')/r^2\phi(r)$ is less than a certain finite quantity. If $\phi(r)$ be a negative power of r, for instance, $\phi(r)=\frac{c}{r^{3-\rho}}$, where ρ is positive, then the force is of the form $\frac{c'}{r^{4-\rho}}$. Whence it follows that Cauchy's hypothesis that the law of forces is the inverse fifth power of r cannot apply to continuous substances.

S. H. B.

487. *Temperature Variations in Higher Atmospheric Strata.* **L. Teisserenc de Bort.** (Comptes Rendus, 131. pp. 920–922, Nov. 26, 1900.)—Continued observations confirm the opinion that the changes of temperature with the seasons decrease in amplitude at high elevations, but that they are still very distinct at altitudes of 10 km.; while the mean monthly values on the surface of the globe show an annual variation of 17°, the variation at an altitude of 5 km. amounts to 14·6°, and at 10 km. to 12°. The zero isothermal is at an altitude of 1,200 m. at the end of winter, and at 3,600 m. in summer; the annual mean of 2,750 m. corresponds with the boundary line of snow in the Alps. The maxima and minima of the higher strata lag behind those of the lower strata; this is particularly striking in the case of the minima which, in the higher strata, fall in March. May is colder than April, and this relapse is quite as pronounced for the isothermal —50° (whose altitude varies between 8,700 and 11,400 m., according to the season) as for the isothermal 0°. [See further Abstract No. 1843 (1899).]

H. B.

488. *Periodical Variations in Glaciers.* **F. A. Forel.** (Archives des Sciences, 10. pp. 401–417, Nov., 1990. Paper read before the Société Helvétique des Sciences Naturelles, Thusis, Sept., 1900.)—Since 1881 the author has published yearly reports on the Swiss glaciers. The variations of glaciers are not merely changes in form, but real changes in volume, which can, as a rule, be determined by measuring the length. There is a yearly variation, and further a period covering about a third of a century (thirty-five years, E. Brückner and E. Richter). The author used to assume that the period of growth lasted on an average 10·5 years, and the period of diminution 27·4 years, giving a cycle of 37·9 years. But the matter is not so simple. The growth does not commence in the same year for all the glaciers of a district, because their snow-feeders are different. A diminution sets in simultaneously for the various glaciers with a hot summer, whose effect extends over several seasons; the stoppage of the feed also causes a diminution. The minimum volume of a glacier must be regarded as its normal size. But every glacier has its own character. H. B.

489. *Distant Thunderstorms observed by the Electro-Radiophone.* **T. Tommasina.** (Comptes Rendus, 131. pp. 876–878, Nov. 26, 1900.)—The author has used his improved carbon coherers [Abstract No. 1295 (1900)] as electro-radiophones for the purpose of detecting thunderstorms too distant to detect in other ways. The electrodes are not metallic, as in earlier forms, but consist of lamp carbons joined to platinum wires; the coherer is hermetically sealed to exclude all moisture. His laboratory on Lake Maggiore is 6 m. above the soil; three copper antennæ, each 30 m. long, were fixed to insulators at a height of 12 m., and one end of each was connected to earth. The antennæ were not fixed vertically, as this position would have rendered the experiments too dangerous, and were completely disconnected and carefully insulated on the approach of a thunderstorm. H. B.

490. *Meteorological Observations during a Petroleum Fire at Bayonne, N.J., July* 5, 6, 7, 1900. **W. H. Mitchell.** (Monthly Weather Rev. 28. pp. 325–327, Aug., 1900.)—At midnight, July 4–5, lightning struck and exploded some oil tanks of the Standard Oil Company. By seven next morning the vanes within half a mile around marked a draught towards the fire. There was but little wind, and the umbrella-shaped smoke column attained a height of 13,411 feet, measured by triangulation. Above that dark column white clouds formed and remained visible for two days in an otherwise cloudless sky. The explosion of three tanks at 10 a.m. on July 5, produced a whirlwind lasting five minutes; in the evening a gas oil tank exploded, the flames shooting up 3,000 feet. The heat of these flames was felt at a distance of 1¼ miles, and was more noticeable at that distance than close to the fire. Local thunderstorms about 4 p.m. on July 6 and 7, possibly connected with the fire, destroyed the smoke column, which disappeared on July 8. Sixteen tanks, each of 30,000 gallons capacity, containing various oils, wax, and tar, were destroyed. H. B.

REFERENCES.

491. *The Reichsanstalt, Charlottenburg.* **H. S. Carhart.** (Amer. Inst. Elect. Engin., Trans. 17. pp. 469–487, Aug. and Sept., 1900.)—A general description of the buildings, and of the nature of the work undertaken.

492. *Chemical Composition of Celestial Bodies.* **A. Ditte.** (Revue Scientif. 14. pp. 609–618, Nov. 17, 1900. Lecture delivered at the University of Paris, Nov. 7, 1900.)—This paper is a concise review of the present knowledge of the chemical constituents of the various cosmical bodies, as determined from spectroscopic analysis. C. P. B.

LIGHT.

493. *On a Property of a System of Wave Normals.* **A. Gleichen.** (Deutsch. Phys. Gesell., Verh. 2. 17. pp. 249–252, 1900.)—The case considered is that of a wave of light passing out of a refracting medium. Consider an element dS of the wave surface. Corresponding to it are two foci, F_1 and F_2, in the wave normal. The distance $F_1 F_2$, known as the "astigmatic difference," is 2Δ. If a section be formed at F between F_1 and F_2 of the pencil of rays which passes through the element of wave surface dS, F_1 and F_2 are on opposite sides of it, the surface being antielastic, and if r_1 r_2 be its principal radii of curvature, $F_1 F_2 = r_1 + r_2$. Let λ be the area of the section at F; λ has its maximum value when $FF_1 = FF_2 = \frac{1}{2}\Delta$.

The point F is defined as the "pole" of the pencil. It has the property that at the pole the curvature of the section is a minimum and its area a maximum. If the radiation from an element dq of wave surface in a cone whose solid angle is ω and direction a, be $E = edqf(a)d\omega$ where c is constant, the intensity at a point in the pencil where the section is λ is $J = E/\lambda$. Let J_0 be the value of J when this section is distant $\sqrt{\Delta^2 + 1}$ from the pole, so that its principal radii of curvature are $\sqrt{\Delta_2 + 1} + \Delta$ and $\sqrt{\Delta^2 + 1} - \Delta$. Then the value of J for a point distant r from the pole is $J = J_0/(r^2 - \Delta^2)$. If $\Delta = 0$, or the pencil is one of ordinary light, J varies as $-\frac{1}{r}$. S. H. B.

494. *Application of the Fourier Expansion to Optics.* **C. H. Wind.** (Phys. Zeitschr. 2. pp. 189–196, Dec. 29, 1900.)—The author supposes that at a point Q a disturbance takes place, concerning which nothing is assumed except that it may be represented by a vector, of which we may study each component separately. If this vector be a function of the time, $f(t)$, we are to consider its value during a finite time T commencing from $t = 0$: $f(t)$ can then be expanded in the Fourier series,

$$f(t) = \frac{1}{T}\int_0^T f(t)dt + \sum_{n=1}^{n=\infty}\left(A_n \sin n\frac{2\pi t}{T} + B_n \cos n\frac{2\pi t}{T}\right)$$

Here—

$$A_n = \frac{2}{T}\int_0^T f(t)\sin n\frac{2\pi t}{T}dt$$

$$B_n = \frac{2}{T}\int_0^T f(t)\cos n\frac{2\pi t}{T}dt$$

If it is allowable to assume that during the interval T, positive and negative values of $f(t)$ are equally represented, the term $\frac{1}{T}\int_0^T f(t)dt$ vanishes. If this assumption is not allowed, then the alternative assumption will be made that $f(t)$ vanishes for $t = 0$, and for $t = T$.

To each member of the Fourier series corresponds a particular vibration. The vibrations which take place during the interval T are not independent of those which immediately preceded that period, nor of those in the immediately succeeding time. Nevertheless, we may consider a period T′ lying within T, such that the influence of the state of the system before and after T on its state during T′ shall be inappreciable, and also so that the differences between T and T′ at either end may be neglected. This is on the assumption, which is legitimate, that T is very great compared with the time of the passage of light through our apparatus. And this assumption being made, it matters not what the state of the system was before T, or will be after T. We may then treat the observed phenomena as represented by an uninterrupted succession of the harmonic terms in the Fourier series.

After discussing the nature of the apparatus, the writer concludes that whether observations are made with the eye or with the photographic plate, we can observe, not separate waves, but only the time average of a number of consecutive waves. The observed vector at P, which corresponds to the disturbance at Q, will then have the form

$$E = \tfrac{1}{2} C \sum_{n=1}^{n=\infty} \Omega_n (A_n^2 + B_n^2),$$

where Ω_n is a function of n whose form depends on the position of P and the nature of the apparatus. For any given apparatus this will generally give different results for different kinds of waves. But this difficulty can be overcome by substituting for the constant C a function γ_n of n, which vanishes for very small values of n, so that the intensity at P is given by

$$B = \sum_{n=1}^{n=\infty} \gamma_n \Omega_n (A_n^2 + B_n^2).$$

The results are as follows: In order to calculate the radiation at any point P in the field, we have first to fix a point of time t_0 at which the radiation in question was emitted from Q; next to choose an interval of time T, such that t_0 is approximately its middle point, and which is the greatest value which has the property that phenomena following each other at an interval less than T are with our apparatus indistinguishable from each other. T being so chosen, we have to take the Fourier series, which expresses the disturbing process during T, and calculate the mean value of $A_n + B_n^2$ for every $\frac{n}{p}$ consecutive values of n, where p is a very great number, so that T/p represents the time of passage of light through the apparatus. That gives an energy curve which we may call the energy curve of the source at time t_0. This energy curve is the only measure of the influence of the disturbance at Q on the observed phenomena. Independently, then, of the uncertainty attending the coefficient γ_n, we cannot determine the separate coefficients of the Fourier series. The utmost we can do is to construct an energy curve which shows the mean values of the squares of the amplitudes for a great number of consecutive terms of the Fourier series.

The writer discusses in a note, on p. 191, Sommerfeld's theory of Impulses [Phys. Zeitschr. 2. pp. 55–60, Oct. 27, 1900. Abstract No. 364 (1901)]. S. H. B.

495. *Ultra-violet Absorption.* **B. Glatzel.** (Phys. Zeitschr. 2. pp. 173–178, Dec. 22, 1900.)—The absorption of ultra-violet light in an alcoholic solution of benzol is much less than the absorption in metals. Alcoholic solutions of anthracene and retene have very high coefficients of absorption, which come up to and even exceed those of all metals except silver. The power of reflexion of metals, as in the visible spectrum, falls off in the ultra-violet with decreasing wave-lengths, except in the case of silver, which has a minimum reflecting power at $\lambda = 322\mu\mu$. The power of reflexion of anthracene and retene for ultra-violet light is not nearly as great as that of the metals; which leads us to suppose that these hydrocarbons are much less absorbent when solid than when in solution, as the mechanical theory of absorption would itself indicate. [See further Abstract No. 1786 (1900).] A. D.

496. *Persistence of Vision.* **F. Allen.** (Phys. Rev. 11. pp. 257–290, Nov.–Dec., 1900. Paper read before the American Association, N.Y., June 27, 1900.)—The author has made numerous experiments to determine the effect upon the persistence of vision of exposing the eye to light of various wave-lengths, and exhibits the results by curves in which ordinates represent the persistence of vision for various parts of the spectrum in seconds, and abscissæ are wave-lengths. The following is the summary of the results arrived at:—

(1) The persistence of all colour impressions reaches a maximum when the eye has been kept open in the dark, the increased duration being unequal for rays of different refrangibilities. The increase is least in the yellow, and grows larger towards both the red and violet. The curve obtained under such conditions may be called the *extraordinary* normal curve.

(2) The persistence of all colour impressions is a minimum when the eye is under the influence of diffused daylight. The curve thus obtained is termed in this paper the *ordinary* normal curve.

(3) When the eye has been blindfolded, the values of the persistence in all cases are intermediate between the extraordinary and ordinary normal curves, showing, however, unequal increases as in the extraordinary curves.

(4) When the retina has been exposed to strong red, green, or violet light, the persistence of impressions of the same colour as the fatiguing light is increased, forming a characteristic elevation or bunch in the part of the persistency curve corresponding to that colour.

(5) When the retina has been fatigued with yellow or blue light, there is no increase in the persistence of impressions of those colours, but the characteristic elevations are produced in the parts of the curves corresponding to red and green or green and violet respectively.

(6) These phenomena confirm the Young-Helmholtz theory as to the fundamental colour sensations.

(7) When the retina has been fatigued with white light, the persistences of all colour sensations are unequally increased. This apparently does not harmonise with the Young-Helmholtz theory, but indicates a partially independent white sensation.

(8) Both rest and fatigue of the retina cause an increase in the persistence of all colours. No explanation of this fact has yet been found.

(9) In the case of naturally colour-blind eyes the persistence of colour impressions to which the retina is blind is abnormally increased, thus affording a method of determining the wave-lengths to which the retina is incapable of responding normally.

(10) In addition to the loss of one fundamental colour sense, the naturally colour-blind retina may also lack the power of responding to a group of waves affecting another sensation. J. J. S.

497. *Spectra of Samarium and Gadolinium.* **E. Demarçay.** (Comptes Rendus, 131. pp. 995–998 Dec. 10, 1900.)—The author, in a previous note

[Abstract No. 2161 (1900)], described the lines of gadolinium between λ 5000 λ 3500. He criticises Exner's work [Reference No. 2424 (1900)], and points out that great care must be exercised in the fractionation of these earths so as to ensure pure spectra. S. R.

498. *Spectra of Radium and Polonium.* **G. Berndt.** (Phys. Zeitschr. 2. pp. 180–181, Dec. 22, 1900. Communication from the Physical Institute of the Halle University.)—The author first employed active barium chloride (activity 240) and active barium bromide, using a platinum spiral heated electrically, so that very small quantities might be used, and examined the spectra for the radium lines. Of these he found only λ = 3814·591 of intensity 2, when the intensities are reckoned from 6 to 1 so that 6 indicates the greatest intensity. On using another specimen of active barium chloride (activity 1000) he obtained λ = 4682·346, Int. 1; λ = 3814·591, Int. 4; and a new line λ = 2708·6, Int. 1. Up to λ = 2100 no more radium lines were found.

The spectrum of active bismuth sub-nitrate (activity 300) was examined photographically, and the author considers the following fifteen lines to belong to polonium :—

Int.	λ	Int.	λ	Int.	λ
1	4596·3	4	3342·0	3	3162·9
2	4007·7	6	3361·5	1	3152·2
4	3821·9	6	3349·2	1	2977·0
3	3467·1	4	3191·2	3	2661·9
2	3462·0	4	3168·2	4	2327·3

As far as λ = 2100 no more lines were found. J. J. S.

499. *Diffusion of Ions.* **J. S. Townsend.** (Roy. Soc., Proc. 67. pp. 122–124, Oct. 26, 1900. (Abstract); Roy. Soc., Phil. Trans. 195. pp. 259–278, Dec. 8, 1900.)—Investigations are described for ions produced in air at various pressures by a radio-active substance and at atmospheric pressure by ultra-violet light and point discharges; also a discussion of conditions requisite to make loss of conductivity due to diffusion during passage along metal tubing very large in comparison with losses arising from recombination or from the mutual repulsion of the ions. The rate of diffusion of the ions into a gas is at pressures below the atmospheric inversely proportional to the pressure of the gas. The negative ions produced when ultra-violet light falls on a zinc plate diffuse into air at nearly the same rate as the negative ions produced by a radio-active substance. The rates of diffusion of ions produced by a point discharge were found to vary considerably according to the position of the point with reference to the metal tube, and are mostly larger than those produced by the other methods. A. D.

REFERENCES.

500. *Comparison Spectroscope.* **C. Pulfrich.** (Zeitschr. Instrumentenk. 20. pp. 299–301, Oct., 1900.)—Description of a spectroscope in which it is arranged that three spectra can be seen at the same time side by side. The instrument is designed for technical use in connection with various colour industries. J. J. S.

501. *Radiographic Stereometer.* **T. Marie** and **H. Ribaut.** (Archives d'Él. Médicale, 8. pp. 289–299, July, 1900.)—An account of the commercial form of the instrument described in Abstract No. 1424 (1900).

HEAT.

502. *Emission Function.* **P. G. Nutting.** (Astrophys. Journ. 12. pp. 208–214, Oct., 1900.)—The Wien-Paschen emission formula for perfect radiators is inapplicable to represent the free emission of *imperfect* radiators in whose emission spectra there are maxima independent of the temperature at particular wave periods. The present paper is an endeavour to construct an emission function of wave-period and temperature which will hold good for the free emission of all substances at all temperatures, including line as well as continuous spectra.

After giving clear definitions of the terms employed, the author commences the discussion by treating the *intensity of emission* as a function of the temperature, and represents it by means of the inverse exponential function—

$$E = a.e.^{-b/T} \qquad (1)$$

Future experimental investigation on the variation of emission at temperatures higher than that of vaporisation may necessitate the inclusion of higher terms, but for the present these are neglected.

Again, the intensity of emission as a function of the wave period is continuous, and is single-valued in the argument for all substances, with all surface conditions, at all temperatures, and has the value zero at zero and infinity, and only at these points. For a perfect radiator it has a single maximum which varies with the temperature. If τ be the period of vibration, we have for a perfect radiator—

$$E = a.\tau^{-n} e^{-\frac{\beta}{\tau}} \qquad (2)$$

Combining equations (1) and (2)—

$$E = A\tau^{-n} e^{-B/\tau T} \qquad (3)$$

which will hold for all substances having but a single maximum, and that varying with the temperature. Its maximum value,

$$E_m = A\left(\frac{n}{Be}\right)^n . T^n . \qquad (4)$$

therefore corresponds to a period $\tau_{max} = \frac{B}{nT}$.

The total intensity of emission at any temperature is the integral of (3) with respect to the wave period, *i.e.*,

$$E_0 = A.B^{1-n}\Gamma(n-1)T^{n-1} \qquad (5)$$

where $\Gamma(n-1)$ denotes the ordinary gamma function.

For the case where $n = 5$, equation (3) is similar to Wien's, and (5) expresses Stefan's law.

Equation (3) cannot represent the free emission from an imperfect radiator, in whose isothermal emission curves there are maxima *not* varying in position with the temperature, *e.g.*, rock salt, when the emission is largely confined to the region near 50μ. To represent this, a sharp maximum is introduced in (8), thus—

$$E = A(\tau - \tau_m)^{-n} e^{-B/\tau T}. \qquad (6)$$

As E must always be real and positive, n is limited to *even*, *whole* numbers, so that we may write—

$$E = A\tau^{-n}(\tau - \tau_m)^{-2} e^{-B/\tau T}. \qquad (7)$$

This formula should hold for any substance having only a single maximum of constant period. As most substances have more than one emission maximum (*i.e.*, spectrum lines), we can generalise (7) for bodies having m such maxima by writing—

$$E = A\tau^{-n} e^{-B/\tau T} \sum_{m=1}^{m} \left(\tau - \tau_m\right)^{-2}, \qquad (8)$$

which should hold for the free emission of all substances.

The author follows the derivation of the formula by a short discussion of the various limits possible, dealing with the influence of the finite *width* of the spectrum lines, the correspondence with curves obtained by other investigators, Rosenthal, Rubens, Aschkinass, &c. C. P. B.

503. *Relations of Radiation to Temperature.* **J. Larmor.** (Nature, 63. pp. 216–218, Dec. 17, 1900. Paper read before the British Association.)—If undulations of any kind are reflected from an advancing wall, there is more energy in the reflected beam than there was in the incident beam, though owing to the Doppler effect its length is shorter, and therefore mechanical work is necessary to push on the wall, and this is directly transformed into undulatory energy. The author shows, in the case of a directly incident wave-train, by applying the condition of zero displacement at the reflector, that the opposing pressure is the fraction $(c^2 - v^2)/(c^2 + v^2)$ of the intensity of the total undulatory energy, direct and reflected, in front of the reflector, c and v being the velocities of propagation of the wave-train and of the advancing wall. By treating the case of oblique incidence and averaging for the natural radiation in an enclosure, it is shown that the pressure is one-third of the total density (E) of radiant energy. From considering a volume V containing radiant energy travelling indifferently in all directions E is proved proportional to $V^{-\frac{4}{3}}$, and, if the original state has the constitution as regards wave-lengths corresponding to temperature T, it follows from Carnot's principle that $T \propto V^{-\frac{1}{3}}$. Thus Stefan's law is deduced, and also Wien's theoretical law, since the Doppler principle shows that in the uniform shrinkage of a spherical enclosure the wave-lengths diminish as the linear dimensions. The relations show that the energy of the radiation corresponding to temperature T and lying between wave-lengths λ and $\lambda + \delta\lambda$ is of the form $\lambda^{-5} f(\lambda T)\, \delta\lambda$. The author defends the thermodynamic treatment of a single ray from the objection that a beam of light is an irreversible agent.

W. E. T.

504. *Radiation of Black Bodies.* **W. Wien.** (Ann. d. Physik, 3. 3. pp. 530–539, Nov., 1900.)—This paper contains a critical survey of some points in the theory of radiation. It deals first of all with Wien's Paradox, in which one of two bodies at the same temperature receives more energy by radiation from the other body than the other receives from it. [See Abstract No. 362, 1901).] The author objects to parallel beams being used, as that is only a limiting case, and he shows diagrammatically a combination of mirrors with the two Nichol prisms and the magnetic field which allows of the difference in paths of the two mutually opposite radiations being made as great as one pleases. The beams being divergent, one body receives only a small fraction of the energy which the other receives. The author points out the analogy between this problem and the one given by Clausius of two mutually radiating bodies at the same temperature but in different media. In order that they shall receive equal quantities of energy it is necessary to assume that the energy emitted by the two bodies is proportional to the square of the refractive index.

Planck has shown that the expansion or extension of radiation is a reversible process if emission, absorption, and dispersion are excluded. Wien considers that it is only reversible when the radiation, by virtue of its pressure, does the maximum possible work in expanding. He presents the following problem in support of his views: Suppose a radiating element at the centre of the diametral plane of a perfectly reflecting hemisphere of radius R_1. All the rays after reflection at the sphere return to the element. If the element is covered with a perfect reflector the radiation in the space will not be altered. If the sphere now gradually expands to radius R_2 work is done by the radiation, and this work will be sufficient to contract the sphere again to radius R_1. But suppose the sphere R_1 to be surrounded by a similar and concentric one R_2 and then R_1 to be suddenly removed or annihilated. The radiation would then extend to R_2, but would be quite different to what would have been present had the body radiated originally to R_2. A fall of temperature has been produced, and no work has been gained.

Two objections have been raised to the assumptions made by the author in deducing his formula for the partition of energy in the spectrum of a black body. The first objection is to the assumption "that the radiation is proportional to the number of radiating molecules"; it is objected to because the radiation from a body is independent of the nature of the molecules. The second objection is that in using Maxwell's law of partition a factor containing the temperature is left out. The author has dealt with the former objection in his Paris Congress address, and contends that the number of molecules is thermodynamically necessary. The second objection is here dealt with at length. If the factor is maintained the formula becomes—

$$E_\lambda = \frac{C}{\lambda^{\frac{13}{2}}\theta^{\frac{3}{2}}} e^{-\frac{c}{\lambda\theta}};$$

but, as he has formerly shown, all formulæ must be rejected which lead to curves steeper towards the axis than the curve

$$\frac{\text{const}}{\lambda^5},$$

i.e., the energy of any wave-length cannot diminish for an increase of temperature. The omission of the factor $(\lambda\theta)^{-\frac{3}{2}}$ is thermodynamically well supported.

The radiation, besides being proportional to the number of molecules, must be also proportional to a certain temperature function, in order that it may at all temperatures be proportional to the number of molecules.

The author considers that the discrepancies found between the law and the experimental results in the case of long waves are to be expected, as he considers that short and long electromagnetic waves do not present only a quantitative difference in their connection with heat radiation. In absorption, long waves are represented by a single vector, since the continuity of matter may be assumed. In short waves the constitution of matter is of influence. Similar considerations must hold for emission. A theory of radiation deduced for short waves cannot be expected to hold for long waves.

Paschen suggests that just as we use different formulæ for slow electric vibrations and for quick ones, so we ought to investigate different formulæ for short and long waves.

Planck in his theory has deduced Wien's law from his expression for electromagnetic entropy. His assumption of "Natural Radiation" has, however, not yet been proved to be the only assumption which will lead to irreversibility. In deducing the expression for the entropy, the resonators are considered as independent, while the deduction depends on several resonators being present. These are the two objections to Planck's theory.

Rayleigh remarked that Wien's law would make the radiation converge towards a limit with indefinitely increasing temperature. Such is the case. At the highest temperatures the increase of energy is only in the short waves. The increase of total radiation still follows Stefan's law. J. B. H.

505. *Thermodynamics and Radiation.* **M. Planck.** (Ann. d. Physik, 3. 4. pp. 764–766, Dec., 1900.)—The author here criticises two of the conclusions which Wien arrives at in his paper, dealing with the theory of the radiation of black bodies [see preceding Abstract.] The first point dealt with is Wien's Paradox in its latest form. Planck considers that if the total radiation into all the surrounding space (which Wien neglects) is included, the compensation will be found which is necessary to satisfy the second law of thermodynamics.

The second point is the question of the reversibility of the free extension or expansion of radiant energy. Wien in his paper gives an example of expansion of radiation in which emission, absorption, diffuse reflection, and bending are excluded, and yet which he considers is not reversible. Planck here points out that the radiation after the sudden removal of the hemisphere R_1 does not distribute itself uniformly along the radius R_2, but that at each instant there are always points on the radius at which there is no radiation in one direction. At periodic intervals also the space between R_1 and R_2 is quite free from radiation, and at any one of these intervals the sphere R_1 may be replaced without the expenditure of energy. J. B. H.

506. *Law of Partition of Energy.* **S. H. Burbury.** (Phil. Mag. 50. pp. 584–595, Dec., 1900.)—A discussion of the Maxwell-Rayleigh treatment of the law of equal partition of energy, and of that due to Boltzmann. The following conclusions are drawn:—

1. The law of equal partition of energy among the translation velocities is not proved by the Maxwell-Rayleigh method.

2. It is not proved by Boltzmann's method, because the fundamental assumption on which that method is based is not proved.

3. Subject to any proof that may be given hereafter of Boltzmann's assumption, the law is not generally true in any sense whatever. When, however, the density is very small, the different energies in question will differ from each other only by small quantities of the second order. The law may therefore be asserted for the limiting case of an infinitely rare gas. [See also Abstract No. 991 (1900).] E. H. B.

507. *Distribution of Energy in the Normal Spectrum.* **M. Planck.** (Deutsch. Phys. Gesell., Verh. 2. 17. pp. 237–245, 1900.)—The author describes a new method of determining, by means of two constants of nature, the distribution of a given amount of energy in the normal spectrum, and the corresponding temperature. He considers a large number of simple vibrators (N with frequency ν, N′ with frequency ν', &c.) in a medium, enclosed by reflecting walls, and in which the propagation of light is c; he assumes E_0 of the total energy (E_t) to be in the vibrators, and E to be in the N vibrators, E′ in the N′, &c. He also assumes E to be composed of a finite number (P) of equal elements of energy (ϵ), putting $\epsilon = h\nu$, where h is a constant, and $E = P\epsilon$, and calls any distribution of these P elements amongst the N vibrators a "Complexion." The number of possible complexions would be $\frac{(N+P-1)!}{(N-1)!\,P!}$, or approximately $(N+P)^{N+P}/N^N P^P$.

The product (R) of the corresponding numbers for all the sets of vibrators is the number of possible complexions corresponding to the assumed distribution of energy. Of all assumed distributions one gives a maximum value (R_0) for R, and the vibrators would take up this distribution in a stationary field of radiation if the E_0 were the energy divisible amongst them. The quotients of E by N, &c., give the stationary values U_ν, &c., of the energies of the individual vibrators of each kind; the equation $u_\nu d\nu = \frac{8\pi\nu^2}{c^3} U_\nu d\nu$ then gives the space density of the vibratory energy in the medium, and thence the energy in the medium is obtainable, and the assumed value of E_0 may be tested and corrected. The corresponding temperature is obtained from the equation—

$$\frac{1}{\theta} = k\,\frac{d \log R_0}{dE_0}$$

This distribution is represented by the expression—

$$u_\nu d\nu = \frac{8\pi h\nu^3}{c^3} \cdot \frac{d\nu}{c^{\frac{h\nu}{k\theta}} - 1}$$

which corresponds to the formula previously given by the author, viz.:—

$$E_\lambda d\lambda = \frac{c_1\lambda^{-5}}{c^{\frac{c_2}{\lambda\theta}} - 1}\, d\lambda$$

The values of the constants, $h = 6.55 \, . \, 10^{-27}$, $k = 1.346 \, . \, 10^{-16}$, were determined from this formula by means of the measurements of Kurlbaum, and Lummer, and Pringsheim. The proof of the validity of the method is based upon the propositions that the entropy of the system in any state is proportional to the logarithm of the probability of this state, and that the probability of every state is proportional to the number of complexions corresponding to it, all complexions being of equal probability.

From a comparison of his own reasoning with that of Boltzmann on gas molecules, the author deduces from k an estimate $(6\,.\,175 \times 10^{23})$ for the number of molecules in the gramme molecule of any element, which agrees with the value determined by Meyer. The values also derived for the mean *vis viva* of an atom at absolute temp. 1°, and for the electric charge on an electron are in fair agreement with previous determinations. W. E. T.

508. *Correction of Wien's Equation.* **M. Planck.** (Deutsch. Phys. Gesell., Verh. 2. 13. pp. 202–204, 1900.)—The author shows that possibly the functional equation from which he had previously deduced Wien's equation [Abstract No. 1446 (1900)] was not sufficient to determine the quantities involved. He therefore assumes, as an arbitrary expression for the entropy, the expression next in order of simplicity to the one which had led to Wien's equation. From this he deduces the energy equation—

$$E = \frac{C\lambda^{-5}}{e^{\frac{c}{\lambda T}} - 1}$$

as a consequence of the electromagnetic theory, and states that it appears to agree with observation, at least as well as the equations of Thiesen, Lummer and Jahnke, or Lummer and Pringsheim. W. E. T.

509. *Theory of the Transition-layer between Liquid and Vapour.* **G. Bakker.** (Zeitschr. Phys. Chem. 35. pp. 598–608, Dec. 7, 1900.)—The author regards it as always possible to substitute for a molecularly constituted medium a continuous medium, so that the attractive forces supposed to act between the volume-elements of the latter will agree with the mean values of the attractive forces acting between the volume-elements of the former medium. It is necessary, however, to distinguish clearly between the law of force between *two molecules* and that between two *volume-elements.* The following theorem is proved :—

"Substituting for the liquid, transition-layer, and vapour, a continuous medium whose density equals that of the body at every point, and whose volume element are subject to attractive forces derived from a potential $-f\frac{e^{-qr}}{r}$, then $3A - 2B = H$, when $A =$ the work required to separate the elements of the medium, $B =$ the virial of the attractive forces, and $H =$ Laplace's constant." F. G. D.

510. *Rankine's Formula for Vapour-pressure.* **P. Juliusburger.** (Ann. d. Physik, 3. 4. pp. 618–659, Dec., 1900.)—The different deductions of Rankine's law,

$$\log f = A - Bt^{-1} - C \log t,$$

for the relation between the absolute temperature t and the saturation-pressure of a vapour f are examined, and are shown to be of the same value, being all founded on the same assumptions. The law is theoretically valid only for very low pressures ; but examination of the observations on 110 vapours shows that, if empirical values are given to the constants, it is of practical use in a much wider range and for some substances may be pushed right up to the critical point. The formula is applicable, too, to a wider range of dissociation-phenomena than has hitherto been suggested. R. E. B.

511. *Illustrations of the Statistical Dynamics of Gas Theory.* **J. Larmor.** (Nature, 63. pp. 168–169, Dec. 13, 1900. Paper read before the British Association.)—It is shown that in a swarm of meteors moving in a conservative field of force there is a quantity which is conserved in each group, viz., the ratio of the density at a group (estimated by numbers and not by size) to the extent of the region on the velocity-diagram which corresponds to it (estimated by divergence from the velocity of the central meteor of the group) ; but this quantity may vary from group to group. This result carries the general law that the concentration in cross-section of a beam of light at different points of its path is proportional to the solid angular divergence of the rays multiplied by the square of the refractive index. Interaction of two streams will cause disturbance, and for the velocities to remain statistically unchanged the particles in each group must range uniformly with respect to distribution in position and velocity jointly; as, however, in this case each value of the resultant velocity would occur with a frequency proportional to its square, a factor such as $exp(-hE)$ is required to keep down very high values, where E is the total energy of a particle and h a constant which defines the temperature. R. E. B.

512. *Gibbs' Thermodynamical Model with van der Waals' Characteristic.* **W. P. Boynton.** (Phys. Rev. 11. pp. 291–303, Nov.–Dec., 1900.)—This characteristic, in its reduced form,

$$(\pi + 3\nu^{-2})(3\nu - 1) = 8\vartheta,$$

where $\pi \equiv p/p_c$, $\nu \equiv v/v_c$, $\vartheta \equiv T/T_c$, the subscripts denoting critical values, leads to the relations

$$\begin{aligned} y \equiv (\phi - \phi_c)/C_v &= \log \vartheta + 8\,a \log \tfrac{1}{3}(3\nu - 1) \\ &= \log \tfrac{1}{4}(\pi + 3\nu^{-2}) + (1 + 8a) \log \tfrac{1}{3}(3\nu - 1), \end{aligned}$$

where $a \equiv R/8C_v$, on the assumption of the constancy of the isometric specific heat C_v, and to the relation

$$z \equiv E/E_c = \{\vartheta + 9a(3 - \nu^{-1})\}/(1 + 18a),$$

on the further (unstated) assumption that $E = 9p_c v_c$ when $T = 0$ and $v = \infty$. Thus by eliminating ϑ and writing $x \equiv \nu$ we obtain for the reduced characteristic surface—

$$(1 + 18a)z = e^y\{(3x - 1)/2\}^{-8a} + 9a(3 - x^{-1}).$$

With the value $a = 1/28$ (*i.e.*, $R/C_v = 2/7$), as suggested by the kinetic theory for triatomic gases such as CO_2, the projections on the xz plane for the isentropics given by $y = -4, -3, -2, -1, 0, 1, 2$ are plotted, and also the projections on the xy plane of the isothermals for $\vartheta = 0{\cdot}25, 0{\cdot}5, 0{\cdot}75, 1, 1{\cdot}25, 1{\cdot}5, 1{\cdot}75, 2$ and of the isopiestics for $\pi = -1, 0, 0{\cdot}5, 1, 2, 3$.

Instability being characterised by $\partial p/\partial v > 0$, *i.e.*, if $\nu > \frac{1}{3}$ by—

$$4\vartheta < \nu^{-3}(3\nu - 1)^2$$

or—

$$\pi < \nu^{-3}(3\nu - 2)$$

or—

$$e^y < x^{-3}\{(3x - 1)/2\}^{2+8a}$$

or—

$$(1 + 18a)z < \tfrac{1}{4}x^{-3}(3x - 1)^2 + 9a(3 - x^{-1}),$$

the projections on the coordinate planes of the curve bounding the region of instability are obtained by substituting = for < in the above, and these are plotted.

Comparison of these results with Maxwell's diagram discloses discrepancies which, the author states, do not disappear on taking the diagram to be drawn in perspective [as should obviously be done]. R. E. B.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

513. *Diurnal Variation of Atmospheric Electricity.* **A. B. Chauveau.** (Comptes Rendus, 131. pp. 1264–1266, Dec. 24, and 1298–1300, Dec. 31, 1900.)—Conclusions are drawn from the results of an uninterrupted series of half-hourly observations made at the Bureau Central Météorologique and at the top of the Eiffel Tower during the years 1893–99. The mean values of the Bureau Central observations have been calculated for the seasons, summer, autumn, and winter, but of the Eiffel Tower readings, for summer and autumn only. It is found that while the mean diurnal potential at the Bureau Central changes from 134 volts in summer to 177 in autumn, the potential on the Eiffel Tower remains nearly constant. Hence the equipotential surfaces near the earth come closer together during the autumn while those at a relatively small distance above it experience no such change. Thus the vertical variation of the field is modified by the seasons; but this modification, though large near the ground, is inappreciable at 30 metres. The variations due to the passage of the negative electricity of the earth into the atmosphere are therefore limited to a very shallow layer of air close to the ground.

Having subjected the results of his observations to harmonic analysis the author (in the second paper) concludes that if the diurnal variation be represented by the sum of five terms of a Fourier series the first two terms will give what may be termed the principal wave and the remainder the secondary one; the latter is of less importance in winter than in summer and not so great on the Eiffel Tower as on the ground. These analytical results confirm the law above stated. [See further Abstracts Nos. 1060 and 1061 (1900).] J. E.-M.

DISCHARGE AND OSCILLATIONS.

514. *Sparking Distances between Plates for Small Distances.* **R. F. Earhart.** (Phil. Mag. 1. pp. 147–159, Jan., 1901.)—The author's experiments were made with exceedingly short sparking distances, so that a very delicate method of measuring the thickness of the separating medium was required. One of the spark terminals was a metal sphere rigidly attached to a fixed support; the other terminal was a disc mounted on a movable carriage which bears one of the mirrors of an interferometer. The distance of separation between the plates is measured by counting the fringes which move across the field of view as the terminals are drawn apart, the passage of one fringe across the field corresponding to the movement of the carriage through a distance of half a wave-length. The only dielectrics used were air and carbon dioxide gas. The results are plotted as curves. In the case of air at atmospheric pressure the curve takes a sudden bend when the distance is between three and four wave-lengths, and the author considers this another argument in favour of the hypothesis of an air-film surrounding the surfaces of the bodies, the thickness of such film being thereby indicated as $1{\cdot}5\lambda$ (sodium light). The curves showing the effect of pressure with air, and the carbon dioxide curves are also discussed in the light of this hypothesis. W. C. H.

515. *Carbon Filaments and Lightning Flashes.* (Correspondence in Electrician, 45. pp. 868 and 869, Sept. 21; and p. 888, Sept. 28, 1900, by the **Editor, W. Langdon, S. P. Blackmore,** and **W. S. Andrews.**)—A curious phenomenon has occasionally been observed in the glow-lamps on the circuits of the Calcutta Electric Supply Company at times when Calcutta has been visited by exceptionally severe thunderstorms. Immediately following each lightning flash the brightness of the glowing lamps has been observed to increase suddenly, gradually returning to its normal value. The editor suggests as a possible explanation that the carbon of the filaments may undergo some kind of "coherer" action, their resistance being temporarily reduced by the electric waves, and then gradually restored through self-decoherence. The correspondents quote various cases of lamps and even dynamo armatures being burnt out, especially in the Transvaal and the Western States of America. E. E. F.

516. *Propagation of Electric Oscillations along a number of Parallel Wires.* **W. B. Morton.** (Phil. Mag. 50. pp. 605–616, Dec., 1900. Abstract of a paper read before the British Association.)—When simple harmonic electromagnetic waves are guided along conducting wires of finite resistance, the effect of the leads is to produce, first, a retardation of the speed of propagation as compared with that in free space, and, second, an attenuation of the amplitude of the waves as they proceed. The determination of these two effects is what is mainly wanted in the solution of the problem. The cases of a single wire in a sheath and a single wire isolated have already been given by J. J. Thomson, and by Sommerfeld respectively. The case for two parallel wires has been treated by Heaviside, and recently very fully by G. Mie. The latter [see Abstract No. 2027 (1900)] obtains a single formula from which the solution can be found to any desired degree of accuracy. The object of the present paper is to show how the *first approximation* to the complete solution may be very simply deduced from the known single-wire solution. This approximation consists in the neglect of the *square* of the small quantity, radius of wire divided by distance apart. A number of cases are now worked in detail on this plan, the chief results being as follows:—

(1) *Two nearly equal Wires.* When two wires are used of which one is, say, 1 per cent. thicker than the other, one being the return wire to the other, then the *larger* wire carries *less* current and surface charge than its fellow. If, however, both wires are similarly charged instead of one being the return, then the larger wire carries the larger current.

(2) *Three Wires in Isosceles Triangle.* If the base wires are the same size and carry equal and opposite currents, the vertex wire is quite free from current. Hence, when two wires are conveying electric oscillations, a third wire equidistant from them plays a passive part. Thus, if there are two pairs of wires at the corners of a *rhombus*, there will be no mutual influence between the pairs. For example, telephone messages sent along the pair at the ends of one diagonal of the rhombus will not be overheard along the other pair.

(3) *Four Wires in Rectangular Arrangement.* When two wires serve as the returns for the other two, the speed and attenuation are the same as if we had *two* wires at distance equal to the product of the two distances of opposite wires divided by the distance of the similar wires; where *opposite* refers to a wire and its return, and *similar* to wires carrying similar currents and charges.

(4) *$2n$ Wires at corners of Regular Polygon, consecutive wires being opposite.* Let r be the radius of the circumscribing circle, then the speed and

attenuation with this arrangement are the same as for a pair of leads at distance $2r/n$.

(5) *n Wires at corners of Regular Polygon, all carrying similar Currents.* In this case, when the skin-effect is marked, the *n* wires produce the same effect on the waves as a single wire of *n* times the perimeter; but when the currents are not concentrated on the surface, but occupy the whole section, the *n* wires can be replaced by a single wire of *n* times the *area*. E. H. B.

517. *Luminescence of a Rarefied Gas surrounding Metallic Wires attached to one of the poles of an Induction Coil.* **J. Borgman.** (Comptes Rendus, 131. pp. 1196–1198, Dec. 24, 1900.)—Continuing his earlier experiments [see Abstract No. 1670 (1900)], the author now describes some further observations on the luminescence produced in a glass tube containing a rarefied gas and having a platinum wire along its axis, when one end of this wire is attached through a condenser to one of the poles of a Ruhmkorff coil whose other pole is to earth, the poles being branched by a spark-gap. The different luminous effects produced according to the dimensions of the tube, the pressure of the gas, and the length of the spark-gap, and according as the positive or negative pole of the coil is attached to the wire, are all described. Still further variations are produced by pasting a strip of tin-foil, connected to earth, on the outside of the tube; and again by using a tube in which there are two wires parallel to the axis and insulated from one another. W. C. H.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

518. *Electrocapillary Phenomena.* **Gouy.** (Comptes Rendus, 131. pp. 939–942, Dec. 3, 1900.)—Helmholtz's theory of the double layer, with the recent addition that the electric layer of the electrolyte is formed of ions, is insufficient. It does not take non-electric forces ("capillary affinity") into account. The electrolyte must be assumed homogeneous; but it can be shown that in the liquid mass the concentration varies with the area of the mercuro-electrolytic surface: and this implies a strengthening or a weakening of the solution in the neighbourhood of this surface; strengthening where the maximum varies in a sense opposed to the concentration, and weakening in the case of so-called active substances. At the maximum, where the mercurial layer is *nil*, the non-electric forces accumulate the anions on the surface of the electrolyte and produce a negative layer, the amount of which varies with the degree of concentration. Behind these there is an equal layer of kathions, held there by electric forces. Where the mercurial layer is positive, there are more anions and more kathions. When it is negative, the electric forces tend to disperse the anions in opposition to the non-electric forces, and may result in the superficial layer being composed of kathions, and in the constitution of the double layer of the ordinary theory. We, have then, to do with three layers (one mercurial and two electrolytic), which may be reduced to two layers. In the theory of capillarity the attractive forces between the mercury and the electrolyte reduce the surface tension; so do the electric forces: and the effect is greater the greater the concentration and the more "active" the anions. At the maximum the mercury is negative to the electrolyte: and the difference of potential between the mercury and the electrolyte is due to the electrostatic action of the different layers described. Let the area of the mercury suddenly increase: electric equilibrium is rapidly restored, all kinds of anions being attracted to form a superficial layer: but gradually the less active anions are replaced by more active ones, and the superficial tension gradually falls. A. D.

519. *Permanent Changes in Metallic Wires, and Variation of their Electrical Resistance.* **H. Chevallier.** (Comptes Rendus, 131. pp. 1192–1194, Dec. 24, 1900.)—The author has already published the results of experiments to determine what permanent changes are produced in a wire of platinum-silver alloy under the influence of temperature, and especially the change produced in its electrical resistance [see Abstracts Nos. 862 and 1857 (1900)]. The object of the present investigation is to determine whether maintaining a steady temperature T in the wire for a certain time, or keeping the wire for the same time at a temperature oscillating constantly between T and $T - \epsilon$, is more effective in producing this permanent change of resistance. The same wire is exposed to a series of heatings, all of the same duration but alternately steady and oscillating, and the resistance is measured during each heating. The temperatures chosen for the experiments are: (1) $T = 320°$, $T - \epsilon = 305°$; (2) $T = 490°$, $T - \epsilon = 470°$. These temperatures are chosen because 320° and 480° correspond respectively to a point of maximum and of minimum in the curve of "limit of limits," explained in the earlier paper [Abstract 1857 (1900)], and a cause of error is thereby eliminated, since at these temperatures the "limit of limits" is independent of the temperature through a range of 30° to 40°. The experiments show that the oscillating temperatures produce a greater change in the resistance than the steady temperatures, and the author concludes that the permanent modifications in the body itself are mostly due to such small oscillations of temperature. W. C. H.

520. *Measurement of Small Electromotive Forces.* **E. Bose.** (Phys. Zeitschr. 2. p. 152, Dec. 8, 1900.)—By means of a millivoltmeter having a resistance of 1 ohm and 150 scale divisions, when arranged as in Fig. 1, potential differences as far as 0·150 volt can be read through compensation.

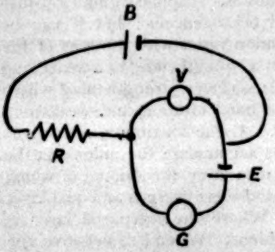


FIG. 1.

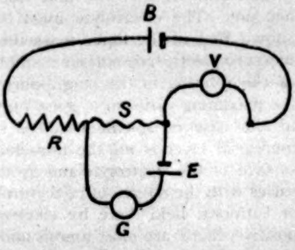


FIG. 2.

In the Figures, E is the e.m.f. to be measured, B the compensating e.m.f., R an adjustable resistance, V the voltmeter, and G a null-instrument. Such a voltmeter permits of the accurate measurement of very much smaller potential differences by making use of subsidiary resistances of $\frac{1}{9}$, $\frac{1}{99}$, $\frac{1}{199}$, $\frac{1}{499}$, $\frac{1}{999}$, and so on, connected to the instrument for current measurement. Such a subsidiary resistance is connected in front of the millivoltmeter, and compensation is made at its ends. Then 9 times, 99 times . . . the value of the compensated e.m.f. is read off on the instrument. The arrangement is sketched in Fig. 2, in which S is the subsidiary resistance. It permits of the measurement of small e.m.f.'s without interpolation, and without a normal element with the help of any resistance-box since the value of this does not come into the measurement. J. J. S.

521. *Ballistic Galvanometer Errors.* **R. Beattie.** (Phil. Mag. 50. pp. 575–579, Dec., 1900.)—When using a ballistic galvanometer of the movable magnet type, unless very great care is taken to have the magnetic axis of the needle exactly in the plane of the coil a source of error is introduced, the magnitude of which is here investigated. The error arises from the magnetic field, caused by the current in the galvanometer coils, having a component along the axis of the needle tending temporarily to alter its magnetic moment. The throw of the needle is not then proportional to Q, the quantity of electricity which traverses the galvanometer, but to—

$$Q + \alpha G\theta \int_0^\tau i^2 dt,$$

where G is the coil constant of the galvanometer, α the induction coefficient of the needle, θ its (small) initial angular displacement, i the instantaneous value of the current, and τ its duration. The value of α is about 0·002.

In discharging a condenser through the galvanometer—

$$\int_0^\tau i^2 dt = \frac{EQ}{2R},$$

and the percentage error becomes

$$50\alpha \, . \, \frac{G}{R} \, . \, \theta E.$$

In a sensitive galvanometer $\frac{G}{R}$ will not differ greatly from unity, so that the error per degree would be only 1 per cent. for E = 600 volts.

The errors are experimentally determined in one particular case, where a condenser is connected in series with a galvanometer across the two poles of a switch which closes a battery circuit of considerable self-induction. On opening the switch the current is broken and the condenser becomes charged through the galvanometer, the energy in the circuit being thereby absorbed. The percentage error in this case is given by—

$$\frac{50\,\alpha G\theta}{QR}(LI^2 + EQ).$$

The experiments were arranged so that the second term was small compared with the first, and the values of θ varied from + 6° to − 4°.

The percentage excess of abnormal over normal throw = $330\,\theta I^2$, which gives the induction coefficient of the needle as 0·0015. J. B. H.

522. *Electrical Measuring Instruments at the Paris Exhibition.* **M. Aliamet.** (Soc. Int. Élect., Bull. 17. pp. 265–325, July–Aug., and 329–402, Sept.–Oct., 1900.)—*Galvanometers.*—The Broca astatic galvanometer has a moving system consisting of two vertical needles, each with a consequent pole at its centre and poles arranged thus : $\begin{smallmatrix} N & S \\ S & N \\ N & S \end{smallmatrix}$; in this way the system is astatic, although the two needles may have different strengths of magnetisation. One pair of bobbins is fixed with its axis at the height of the consequent poles, the end poles being outside the bobbins. This galvanometer is made by J. Carpentier, who also exhibited a ballistic d'Arsonval galvanometer fixed on a Julius suspension. The moving coil, of 500 ohms resistance, is very long in a horizontal direction so as to increase the moment of inertia ; the period is 8 seconds, and 1 microcoulomb gives a throw of 40 mm. on a scale at a distance of 1 m. The Julius suspension consists of three metallic wires fixed to the ceiling and attached to the galvanometer at three clamps in a plane containing its centre of gravity. To avoid swinging, vanes dipping in oil are attached to the bottom of the galvanometer. Ducretet showed a registering d'Arsonval galvanometer with six circular magnets fixed horizontally; the moving coil carries a flexible arm terminating in a pen, which is pressed against the registering drum at intervals by means of an electromagnet. Hartmann and Braun exhibited several types of galvanometer, among which a portable mirror galvanometer is worthy of mention. This carries on one tripod a scale and telescope supported on an arm which is jointed in the middle of its length, so as to bring the telescope and scale close to the body of the galvanometer when it is required in a portable form; a clamp is provided to fix the moving system. Callendar's registering galvanometer, made by the Cambridge Scientific Instrument Company, is arranged to register resistance measured on a Wheatstone bridge, or potential on a potentiometer. A deflection on the galvanometer closes one of two relay circuits and releases a clockwork mechanism, which moves a carriage along the slide wire of the bridge in one direction or the other until balance is obtained. The carriage also carries the registering pen. To ensure the galvanometer making contact with very slight pressure, two contacts, carried by an arm attached to the moving coil, are arranged one on each side of an insulating disc, covered on each face with platinum. This disc is revolved continuously by clockwork, and its surfaces are kept clean by rubbers.

Galvanometer Accessories.—Hartmann & Braun exhibited two supports for scale, telescope, and lamp. One consists of a tube fixed vertically to the wall, which carries an arm capable of up-and-down motion, and balanced by a counter-weight in the tube. The end of the arm carries the telescope, scale, and lamp, with various rack and worm-wheel adjustments. The second support is in the form of an inverted pyramid, arranged to run along a beam fixed to the ceiling; the telescope is fixed to the lower end, and carries the scale fixed to its body. In Siemens and Halske's arrangement the lamp and scale are immediately below the galvanometer, and the incident and reflected lights are reflected at right angles by a total reflection prism placed near the galvanometer mirror.

Ammeters and Voltmeters.—A large number of these instruments of the d'Arsonval type are exhibited, but present no novel features. The Caron alternate-current ammeter, made by the Société Industrielle des Téléphones, consists of a pair of horseshoe electromagnets acting on a flat, oblong coil which is pivoted at one end. The magnet poles embrace the edges of the coil, which is connected in series with the magnets. The current causes the coil to move in its own plane from one magnet towards the other. The coil is connected through a pair of levers with the needle, and is damped by a pair of air dash-pots. The current is introduced through a transformer, with a single turn in the primary, and a high-resistance secondary. The voltmeter is exactly similar, except that the magnets are wound with German silver to diminish the effect of their self-induction. The indications vary slightly with the frequency, but this variation may be compensated by inserting a transformer with a high-resistance primary coil. Siemens and Halske showed a rotary field ammeter, constructed on the lines of a four-pole induction motor, with an aluminium drum as rotor. The current passes through one pair of field-coils, while the other pair are short-circuited on themselves. The control is a spiral spring, and oscillations are damped by permanent magnets embracing an auxiliary aluminium disc. Horn constructs an electromagnetic voltmeter with two scales, one in black for continuous currents, the other in red for alternate currents. Two short cylinders of sheet-iron are supported eccentrically in a solenoid, one on each side of the axis and at each end of the solenoid. Their motion, under the influence of the field in the solenoid, tends to place them coaxial with the solenoid, and it is transmitted to the needle by a jointed frame, which serves also as their support. A novel exhibit is Arnò's electrostatic voltmeter, based on the principle that a dielectric in a rotary electrostatic field tends to rotate with the field by reason of the lag in its polarisation. Three segments of a metal cylinder, which are connected to a three-phase supply, surround a paraffined paper cylinder; the rotation of the latter is controlled by a spiral spring. The scale has exactly equal divisions.

Resistances.—The instruments in this section were all of well-known types, and call for no special mention. Chauvin and Arnoux employ constantan in the construction of their resistances, and, to avoid the effect of the high thermoelectric power which this alloy possesses, the terminals, slides, and all fittings of their resistance-boxes are also of constantan. The Physical-Technical Institute of Charlottenburg showed high resistances made by Kundt's process: a mixture is made of gold and platinum chloride in camomile oil, and a spiral line is painted on a porcelain tube by a brush dipped in the mixture; this spiral is reduced to the metallic state by burning in a muffle, and then possesses a very high resistance.

Potentiometers.—Chauvin and Arnoux showed a portable potentiometer with slide wire, similar in arrangement to Crompton's potentiometer. The slide-wire contact is adjustable relatively to its index, so as to compensate for the temperature variation of the standard cell. A scale is provided marked in degrees Centigrade.

Ohmmeters.—Direct-reading instruments having one fixed and one moving coil were shown by Carpentier, Hartmann and Braun, and Siemens and Halske. The first maker also showed an ohmmeter with two fixed coils, acting on a soft iron needle; the pointer attached to this is prevented from oscillating by a fork which allows it only a limited motion; the fork is moved by a milled head to the position of equilibrium of the needle.

Earth Detectors.—Siemens and Halske exhibited an electrostatic voltmeter adapted to the purpose of indicating the insulation of live conductors; the two conductors of a line are connected to the two pairs of quadrants, the other needle is connected to earth. If the insulation of one conductor diminishes the needle deflects towards the quadrants to which the other conductor is connected; there is, however, no deflection in the case of both conductors equally diminishing in insulation. Arnò has devised similar instruments for three-phase circuits, based on the principle of his electrostatic voltmeter.

Condenser Standards.—Carpentier makes standard condensers formed of sheets of mica silvered by chemical deposition. Keiser-Schmidt showed a condenser having a very small residual charge with a dielectric formed of chemically pure paper impregnated with an insulating material, the nature of which is kept secret.

Wattmeters.—With the exception of the induction wattmeters made by the Allgemeine Elektrizitäts-Gesellschaft, all those exhibited were of the electro-dynamometer type, either with torsion head or direct-reading. Siemens and Halske make non-inductive resistances for connecting in series with the pressure coil of their wattmeters by winding flat wires on thin sheets of mica, the requisite number of sheets being fixed side by side in a box about 7 mm. apart.

Phasemeters.—In the Siemens' type two coils, carrying the two currents, are placed perpendicularly, and produce a rotary field whose amplitude varies with the difference of phase between the two currents. Its amplitude is measured by the rotation of a metallic disc, embraced by the coils, and controlled by a spring. Arnò's phasemeter consists of an electro-dynamometer with torsion head, the two coils carrying the two currents. Inside these coils is suspended a pair of coils fixed perpendicularly to each other and short-circuited on themselves. This system is also provided with a torsion head. From the readings of the two torsion heads may be calculated the tangent of the angle of phase-difference.

Curve-tracers for Alternate Currents.—Abraham's rheograph differs essentially from Duddell's in having a galvanometer coil of very long period. In order that the force acting on the coil may be at all times proportional to the current this is transformed as follows: The transformer consists of two pairs of flat coils, one pair within the other, and relatively adjustable in respect to their planes. The current undergoes double transformation, the secondary of the first pair of coils being in series with the primary of the second. The fourth coil is in series with the galvanometer coil and with an adjustable resistance in the main circuit of the first coil, and also receives an induced e.m.f. impressed by the first coil, and adjusted by varying the relative inclinations of the planes of the coils. These adjustments are made till the galvanometer correctly registers the curve of an interrupted continuous current. An interrupter for this purpose is fixed on the shaft of the synchronous motor provided with the instrument. Stieberitz, of Dresden, showed a curve-tracer with a galvanometer having a period of only 0·0001 second. For a current of 100 ∿ the apparatus traces one complete curve in two seconds. Ganz & Co. showed a Joubert contact-maker designed by Hoor, which can be held in the hand and pressed against the alternator shaft like a speed-counter.

Permeameters.—Carpentier's permeameter consists of a massive iron ring with two air-gaps diametrically opposite. In one is suspended a magnetised needle with torsion head and scale. The test-rod, surrounded by a magnetising coil, is fixed across the ring on a diameter perpendicular to that on which are the air-gaps; the induction in the test-rod is then proportional to the torsion required to bring the needle to zero. The effects of hysteresis are eliminated by a double reading as follows: After the needle has been brought to zero by turning the torsion index the scale is turned round so as to bring the zero under the index; the current is then reversed and the torsion head turned to bring the needle to zero. Its reading then gives directly the value of the induction. An ammeter is provided reading directly in maxwells. Hartmann and Braun make a complete apparatus for measuring permeability by means of a bismuth spiral; it contains an iron yoke to take the test-pieces, an ammeter, and a slide-wire resistance bridge to measure the variations in resistance of the bismuth spiral. Siemens and Halske's permeameter, designed by Kath, consists of a d'Arsonval galvanometer, an iron yoke with magnetising coil replacing the usual permanent magnet. The test-rod completes the magnetic circuit of the yoke and carries the coil. A constant current is passed through the moving coil, the index of which moves over an arbitrary scale, calibrated in gausses. Two small coils, in series with the magnetising coil, but wound in the opposite direction, compensate for the field due to the yoke itself. G. H. B.

523. *An Electric Micrometer.* **P. E. Shaw.** (Phil. Mag. 50. pp. 537–562, Dec., 1900. Paper read before the Physical Society of London, March 23, 1900.)—The amplitude of vibration of a telephone diaphragm is here experimentally measured by a micrometric arrangement. A fine micrometer screw moves the first of a system of three levers arranged so that the motion of the free end of the third lever is about one-thousandth part of the motion of the micrometer screw. A platinum point fixed to this free end makes contact on a platinum-iridium disc on the telephone diaphragm. This contact closes a circuit through a cell and a telephone receiver which the observer holds to his ear, and he thus knows immediately a contact is made. Currents of different strengths are sent through the coils of the telephone under examination, and the corresponding motion of the diaphragm is measured. By this means a curve is plotted, giving the connection between current-strength and motion of the diaphragm. To determine the motion corresponding to the limits of audibility, the current is measured which when made and broken in the telephone receiver just produces an audible sound when the receiver is held to the ear. By extrapolation from the above curve the corresponding motion of the diaphragm is obtained.

The connection between the diaphragm motion and the sound produced is given as follows :—

1.	Begins to be audible	0·4 μμ
2.	„ „ comfortably loud	50 „
3.	„ „ uncomfortably loud	1000 „
4.	„ „ overpowering............................	5000 „

The author considers that the method of electric contact here adopted has proved reliable, and that the lower limit of the lengths which can be measured by this means is much lower than that attained by the optical methods depending on some wave-length. The difficulties arising from vibration of the building and from temperature differences were successfully overcome.

J. B. H.

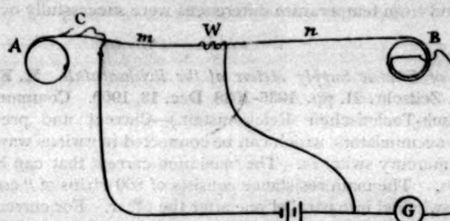
524. *Tests of Electric Supply Meters at the Reichsanstalt.* **K. Feussner.** (Elektrotechn. Zeitschr. 21. pp. 1035–1038, Dec. 13, 1900. Communicated by the Physikalisch-Technischen Reichsanstalt.)—Current and pressure are obtained from accumulators, which can be connected in various ways in series or parallel by mercury switches. The maximum current that can be taken is 10,000 amperes. The main resistance consists of 800 strips of "constantan,' which can be switched into parallel one after the other. For currents higher than 6,000 amperes, a water-cooled tubular resistance of about 0·002 ohm is joined in parallel with the strips. Portable slide-wire rheostats are used for exact adjustment with moderate currents. Measurements of current and pressure are mostly made with instruments of the Weston type. Times are taken either by a stop-watch or by a recording chronograph : the latter admits of at least twice the accuracy of the former, and hence saves time in testing. No meter has hitherto been found sufficiently accurate to serve as a standard. In the case of meters for large currents, the current in the leads has often a perceptible effect on the readings, and the tests are therefore carried out with the leads in the position which they will have when the meter is in use, this position being specified on the certificate of the test. It has been found advisable to measure the resistances of the meter first of all. The rate of the meter is taken by short tests, at ⅕, ½, and full load, and it is then run at full load for an hour. W. H. E.

525. *Testing Alternate-Current Supply Meters.* **E. Orlich.** (Elektrotechn. Zeitschr. 22. pp. 94–98, Jan. 31, 1901. Communicated by the Physikalisch-Technische Reichsanstalt.)—A detailed description of the arrangements adopted by the Reichsanstalt for calibrating single-phase and polyphase supply meters of various types. The pressure-coil of the meter having been connected for half an hour to a source of e.m.f. corresponding to the specified p.d., the constant of the meter is determined for the following conditions of use :—

Current	0·2 of full-load	0·6 of full-load	Full-load	Full-load	Full-load
Power-factor	1	1	1	0·6	0·2
				or 0·5	

The readings having been taken, the meter is kept working at full load for one hour, and then the above series of readings is repeated in the reverse order. If the time required to make the measurements be included, then on the whole the meter is kept working at full load for about two or three hours. In making a measurement, the wattmeter readings (there are always 2 wattmeters in circuit) are taken first, then the time measurement, and finally the wattmeter readings again. The currents for the meter are supplied by two transformers connected to a three-phase generator driven by a continuous-current motor which receives current from a set of large storage cells. The phase-shifting device consists of an induction motor whose rotor may be fixed in any desired position relatively to the stator. A. H.

526. *Fault-Finding on Cable Drums.* **R. Appleyard.** (Phys. Soc., Proc. 17. pp. 104–107, July, 1900.)—The rubber-covered cable is wound off drum B, on to drum A, while the galvanometer G is connected to the core as if insulation were being taken by direct deflection. W is a wire spiral and C is a wet cloth outside the cable. If there is a single fault only, the deflection of G falls when the fault passes under the guard wire. If there are several faults the deflection falls for each one. If *r* is the ordinary dielectric resistance of the total length of core when there is no fault ; *m* and *n* ohms are the surface resistances between the guard wire W and A and B respectively ; *f* the resistance of the fault ; *b* the battery resistance ; *g* the galvanometer resistance ; E the e.m.f. of the battery, then the current G in the galvanometer is given by—



$$G = \frac{E}{(r+g+b) + \left\{\frac{g}{m}(r+b) + \frac{b}{n}(r+g) + \frac{brg}{mn}\right\}}.$$

M. O'G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

527. *Chemical Formulæ and the Invariant Theory.* **P. Gordan** and **W. Alexejeff.** (Zeitschr. Phys. Chem. 35. pp. 610–633, Dec. 7, 1900. From the Report of the Meeting of the Physico-Medical Society at Erlangen.)—The authors have investigated more closely the analogy between the algebraical theory of invariants and covariants and the atomic theory of chemistry, noticed by Sylvester and Clifford (Amer. Jour. of Math., 1878). They represent invariants and covariants by symbolic products arising from the combination of the symbols of the given algebraical forms, and they apply the same symbolic products to represent the constitution formulæ of chemical compounds and radicals. An element-atom and a quantic of the same degree as the valency of the atom are represented by the same symbol; thus $c_x c_x c_x c_x$ or c_x^4 is the symbolic expression for the biquadratic form and for the carbon atom. Symbolic products are formed by combining and enclosing in brackets a pair of symbols, as $(c\,h)$ is formed from c_x and h_x; to this corresponds the process of saturation of valency, $(c\,h)c_x^3$ representing the radical $-\overset{|}{\underset{|}{\mathrm{C}}}-\mathrm{H}$. For example, the symbolic product $(c_1c_2)(c_2c_3)(c_1h)^3(c_2h)^2(c_3h)^2(c_3o)(o\,h)$ represents the constitution of primary propylalcohol and an invariant of the corresponding quantics, viz., the biquadratic, quadratic, and linear forms. The presence of a complex (θ) of symbolic factors (called the *reducent*) affords a convenient way of dividing chemical compounds into classes and subclasses, each class being characterised by its reducent.

When the process of combination is applied a given number of times to two given covariant forms, a series of symbolic products arises, called *equivalent* in the invariant theory, just as a series of isomers arises from two given radicals: as an invariant may break up into factors, so may an isomer break up into groups of molecules. If two members of the series are known the intermediate members can be interpolated by interchanging two symbols with one another in a pair of symbolic factors, as by interchanging c_1 and c_2 we pass from $(c_2c_3)(c_1h)$ to $(c_1c_3)(c_2h)$; this process is compared with the process going on in chemical reactions. The process of deriving chemical compounds from given compounds is also compared with the processes of evection and transvection, isomers appearing as members of a transvection.

The symbolic representation is applied to the grouping and derivation of actual chemical compounds; three classes of forms with open reducents, leading to the ethyl, ethylene, and ethenyl series of compounds with their alcohols, ethers, acids, amides, ketones, &c., are discussed; the analogy of invariants with closed reducents to the aromatic compounds is exhibited, and finally the symbolic method is applied to an analysis of the indigo formula. W. E. T.

528. *Stassfurt Salt Deposits and the Maximum Tension of Solutions.* **J. H. van't Hoff** and **H. v. Euler-Chelpin.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 46. pp. 1018–1022, Nov. 15, 1900.)—The present paper contains an experimental determination of the maximum tension at 25° of solutions of different sulphates and chlorides of magnesium, potassium, and sodium and mixtures of these, each solution being saturated with sodium chloride. The

results are given in a long table in the paper, first for sodium chloride alone, then for solutions of sodium chloride and one other salt, then sodium chloride and two salts, and lastly for sodium chloride and three other salts. The results are then represented in an interesting triangular diagram, the three sides of which correspond to absence of sulphates, magnesium, and potassium respectively.

The present measurements confirm the formation of a lower hydrated form of gypsum, and also the formation of "Kainite" ($MgSO_4 . KCl . 3H_2O$) at 25°.

[For former papers on the Stassfurt salt deposits see Abstracts Nos. 226, 1114, 1116, 1879 (1900).] J. B. H.

529. *Physico-chemical Studies of Tin. III.* **E. Cohen.** (Zeitschr. Phys. Chem. 35. pp. 588–597, Dec. 7, 1900.)—Stockmeier describes a case of "tin-plague" at Rothenburg, where during the winter of 1893 the dipped tin-plate of the roof of the post office was attacked, whilst the rolled tin-plate of the town hall escaped, and quotes a statement of Lewald to the effect that the crumbling of tin is due to a strain in the material, and only occurs in block tin, and not in rolled tin. This is incorrect, since tin filings are changed into grey tin by long cooling. Since 1893, although the winters have been less severe, the rolled tin of the Rothenburg town hall has also become "infected," and grey tin has begun to appear. In order to ascertain the effect of vibration, a plate of tin was kept at a temperature between 5° and 12°, and rattled continually during three months, but did not undergo change. The maximum velocity for the conversion of white tin into grey tin was previously found to occur at —45°, but this temperature is largely affected by the previous treatment of the tin and by the presence or absence of "pink-salt" in the dilatometer. In presence of a 10 per cent. solution of "pink-salt" the maximum velocity of change in a sample of white tin, prepared by warming grey tin, occurs at 0°, whilst with no "pink-salt" it is at about —45° C. [See further Abstracts Nos. 878 and 1517 (1900).] T. M. L.

530. *Demonstration of Electrolytic Solution-pressure.* **W. Palmaer.** (Zeitschr. Elektrochem. 7. pp. 287–289; Discussion, pp. 289–290, Nov. 15, 1900. Paper read before the Deutsch. Elektrochem. Gesell. at Zürich, Aug., 1900.)—Owing to its small solution-pressure mercury becomes positively charged even in contact with an N/2000 solution of a mercurous salt. This charge is acquired by the removal of mercury ions from the solution, and if mercury is sprayed into the solution the latter becomes poorer in mercury at the point where the spray enters. The surface of the mercury at the bottom of the vessel is already in equilibrium with the solution, and the positive charge is therefore given up to the solution, which thus becomes richer in mercury. This difference of concentration can be demonstrated by forcing mercury through a large number of minute apertures and allowing it to fall through a mercurous solution contained in a vessel designed to prevent the mixing of the solution. The concentrations found were in the proportion of 0·51 : 1 : 1·41 at the top, middle, and bottom of the vessel, and similar changes of concentration were found in the case of the anion. [See also Abstract No. 1226 (1899).] T. M. L.

531. *Vapour-pressure Relations in Mixtures of Two Liquids. III.* **A. E. Taylor.** (Journ. Phys. Chem. 4. pp. 675–689, Nov., 1900.)—The measurements already described have been used in order to ascertain whether

Henry's law and van't Hoff and Raoult's law of the decrease of vapour-pressure hold good for mixtures of acetone and water.

Henry's law as to the proportionality of the partial pressure (p) of one component with its concentration (c) in the solution, does not hold good. In the case of the water p/c is fairly steady only at low concentrations, but $p/\sqrt{c}$ is moderately constant up to a fairly high concentration, showing that polymerisation occurs, and that double-molecules of water are probably present in the solution, together with simple molecules, and possibly with molecules of still greater complexity. In the case of the acetone $p/\sqrt[3]{c}$ is most nearly constant, and the degree of polymerisation is evidently greater than in the case of the water. Large deviations occur in the formulæ for acetone and for water when these are present in the solution in an excessively large proportion.

The van't Hoff-Raoult formula allows of the prediction from the composition and vapour-pressure of the solution of the composition of the vapour; the calculated and observed values only differ by a small percentage, and are probably within the limits of experimental error. But when the vapour-pressure is calculated from the composition of the solution and of the vapour the experimental errors in the latter are so magnified that large discrepancies occur. [For preceding parts see Abstract No. 2068 (1900); *cf.* also following Abstract.] T. M. L.

532. *Vapour-pressure of Binary and Ternary Mixtures.* **F. A. H. Schreinemakers.** (Zeitschr. Phys. Chem. 35. pp. 459–479, Nov. 20, 1900. Communicated in outline to the Königl. Akad. der Wiss. Amsterdam, April 21, 1900.)—The composition of the vapour-phase in contact with two liquid phases containing phenol and water has been determined at different temperatures; the percentage of phenol increases from 5·96 per cent. at 29·8° to 8·66 per cent. at 64·4°, but is always less than the percentage of phenol in the aqueous layer; on distilling at constant temperature, therefore, the aqueous layer will gradually decrease, and the vapour-pressure will remain constant until only the phenolic layer remains.

The composition of the vapour-phase in contact with a single liquid phase has also been determined at different temperatures. The composition of vapour and liquid are identical for solutions containing 5·5 per cent. phenol at 56·3°, 7·2 per cent. phenol at 75·0°, and 8·29 per cent. phenol at 90°; such solutions distil unchanged; solutions containing larger amounts of phenol give a distillate containing less phenol than the solution, and would therefore be concentrated by distillation; the converse holds for solutions containing less phenol.

The total vapour-pressure, p, and the percentages of phenol, x_v and x_s, in the vapour and solution are related by van der Waals' equation—

$$\frac{dp}{dx_v} = \frac{p(x_v - x_s)}{x_v(1 - x_v)};$$

a satisfactory agreement between theory and experiment was observed on calculating ΔP from the observed values of x_v and x_s.

In the case of aniline and water the composition of the vapour-phase is intermediate between that of the two liquid phases, where these are present. At 56·3° and at 75° aqueous solutions of aniline were found to contain a much smaller percentage of aniline than the vapour in contact with them. As before, satisfactory results were obtained on calculating ΔP from x_v and x_s.

Values are also given for the vapour-pressures of ternary mixtures of water, phenol, and aniline at 56·3°. [*Cf.* preceding Abstract.] T. M. L.

533. *Determination of Distribution of the Current on the Surface of Electrodes.* **K. Norden.** (Zeitschr. Elektrochem. 7. pp. 309–313; Discussion, pp. 313–315, Nov. 22, 1900. Paper read before the Deutsch. Elektrochem. Gesell. at Zürich, Aug., 1900.)—The author states that if the determination is attempted simply with two opposed electrodes, no satisfactory results are obtained. By intercepting a third electrode, more satisfactory results are found, as the opposed surface in this case acts as a separate electrode. Early experiments by A. Tribe [Phil. Mag. (5) 11, 1881], G. Wiedemann, and particularly J. Stark [Wied. Ann. 66. p. 245, 1898, Abstract No. 301 (1899)], are referred to.

Heinz (Zeitschr. Elektrochem. IV. p. 527) has also employed a similar device for experiments on polarisation.

Sulphate of copper solution, with an intermediate very thin insoluble plate, or a mixed electrolyte of zinc and copper sulphate, in which latter case a very characteristic gradation of various shades of brass deposits are obtained, are recommended. Most characteristic and satisfactory results were obtained when the intermittent electrode was placed in an inclined position. Some reference is made to the question of accumulator plates.

O. J. S.

534. *Electrolytic Lead Bisulphate.* **K. Elbs** and **F. Fischer.** (Zeitschr. Elektrochem. 7. pp. 343–347, Nov. 29, 1900.)—The preparation of lead bisulphate, $Pb(SO_4)_2$, by chemical methods is unsatisfactory and difficult, but the compound is readily obtained as a nearly white, insoluble precipitate by the electrolysis of sulphuric acid of sp. gr. 1·7–1·8, using lead electrodes and a current density of 2–6 amperes per square decimetre. The temperature should not rise above 30°, otherwise more or less decomposition of the bisulphate will occur. Lead bisulphate is soluble in concentrated sulphuric acid to the extent of about 0·3 per cent.; it is instantly decomposed by water with the formation of sulphuric acid and lead peroxide. The chemical reactions of lead bisulphate and some compounds of it with other sulphates are described in the paper, much of which is mainly of chemical interest. This compound is, however, of significance in the theory of accumulators, as has previously been pointed out [see Abstract No. 1743 (1899)]. For if, in consequence of an insufficient degree of porosity in the active material, or of the use of too strong a charging current, the sp. gr. of the acid in the interstices of the positive plate rises above 1·65, lead bisulphate is formed, and the production of lead peroxide is prevented. A portion of the bisulphate, moreover, acts on the lead plate with the formation of ordinary lead sulphate.

N. L.

535. *Electrolytic Production of Benzidine.* **W. Löb.** (Zeitschr. Elektrochem. 7. pp. 320–328, Nov. 22; and 333–338, Nov. 29, 1900.)—The author arrives at the following conclusions:—(1) In forming benzidine electrolytically in an acid solution, the rate of change from intermediately formed hydrazobenzene bears a direct relation to the rate of reduction. (2) If an acid reduction is attempted nitrobenzene cannot be employed, as the intermediate products, such as phenylhydroxylamine, much decrease the yield of benzidine. (3) As a starting-point for acid reduction, azo- or azoxy-benzene, both of which can be easily prepared by electrolysis, should be used; these on further reduction yield benzidine with an excellent efficiency of 80 per cent. (4) Mercury kathodes are most suitable for all these operations. The stirring of the electrolyte is of importance as regards yield. [See also Abstract No. 186 (1901).]

O. J. S.

536. *Sterilisation of Water by Ozone.* **Thomæ.** (Zeitschr. Vereines Deutsch. Ing. 44. pp. 1685–1688, Dec. 8, 1900.)—The author gives a general summary of the progress made in generating ozone by the electrostatic method, and enumerates the various forms of ozoniser that have been been designed for this purpose. He then gives a detailed account of the exhibit of the "Société industrielle de l'ozone" at the recent Paris Exhibition. This Company now owns the Marmier and Abraham patents, and has two installations at work, namely, at Lille and at Boleo in Mexico. In the latest form of ozoniser hollow electrodes are used, cooled by water. Glass is used as dielectric, with a pressure of 40,000 volts. The author considers that the cost of sterilising by this method, namely, 0·01 frc. per cub. metre, requires confirmation. The report of the Lille Medical Commission is finally quoted. [See Abstract No. 1755 (1899).] J. B. C. K.

537. *Haas and Oettel's Electrolytic Bleaching Apparatus.* **F. Oettel.** (Zeitschr. Elektrochem. 7. pp. 315–320, Nov. 22, 1900.)—A rectangular box is divided into compartments by means of vertical carbon electrodes fitting into recesses. The negative end-electrode consists of a stout lead plate, and the intermediate bi-polar electrodes of specially prepared carbon plates 1 c.m. thick, the positive end-electrode being formed by two such plates. A current density of 1,000 amperes per square metre is employed, the electrodes being totally immersed so that no chlorine is given off on the surface. Any loose carbon dropping down settles at the bottom. A brine solution of density 6 Bé. forms the electrolyte which passes alternately over the top and under the bottom end of the carbons. By noting the increase of temperature between the electrodes, and the flow of liquor, the quantity of hypochlorite formed is checked.

The whole apparatus can be tilted on one side, cleaning thus being facilitated. If strong hypochlorite solutions are required, artificial cooling must be applied.

With an initial concentration of 2·55 gr. per litre, and a current of 61 amperes per apparatus, the amount of power expended per kg. of chlorine was 4·48 h.p. hours. With a run of ten hours, 14·81 grs. per litre were obtained for an expenditure of 8·11 h.p. hours. These strong hypochlorite liquors render it a feasible project to introduce the apparatus into paper-works. O. J. S.

538. *Electrolytic Oxygen and Hydrogen for Industrial Purposes.* **O. Schmidt.** (Zeitschr. Elektrochem. 7. pp. 295–298; Discussion, pp. 298–300, Nov. 15, 1900. Paper read before the Deutsch. Elektrochem. Gesells. at Zürich, Aug., 1900.)—The general form of apparatus used for the electrolytic decomposition of water upon a practical scale consists of an iron vessel with iron electrodes, into which an alkaline electrolyte is fed. At the anode the iron assumes the passive molecular condition, and oxidation only occurs when the current density or the concentration of the electrolyte is too high.

The more commonly known electrolysers have, however, many disadvantages, and the author has brought out an improved form. It is based upon the filter-press principle, and consists of a number of narrow, square iron frames, each separated from its neighbours by asbestos cloth, and each containing an iron electrode. Any number of these frames can be built up to form one many-celled electrolyser. The current passes from one cell to the next by the double pole iron electrodes, and the hydrogen and oxygen liberated in each cell division are separately collected and stored in two gasholders attached to the apparatus. This improved form of electrolyser is said to be already adopted in several small establishments where oxygen and hydrogen are used for various purposes. The e.m.f. required to work it is 2·5 volts, and a yield of 168 litres of hydrogen and 84 litres of oxygen per kw. hour can be obtained. This represents an energy efficiency of 54 per cent. The gases obtained are not quite pure; the oxygen contains 2 per cent. of hydrogen, and the hydrogen 1 per cent. oxygen, but for industrial use these percentages are unimportant. Oxygen and hydrogen produced by electrolysis are already being employed in accumulator works for burning lead joints; electrolytic hydrogen is being used for inflating military balloons, and may find a wide field of employment as a lighting agent. Burnt in a suitable burner, hydrogen is a cheaper illuminant than acetylene, the relative costs for equal illuminating power being as 25 to 59. The chief difficulty which hinders the adoption of compressed hydrogen as a lighting agent is the cost of transporting the steel cylinders in which it is stored and sold. Hydrogen is also one of the cheapest carriers of energy for power purposes, Borchers having shown that 1-h.p. hour generated from electrolytic hydrogen will cost only 3·02 pfge., as compared with 3·82 pfge. when acetylene gas is used.

The author at the conclusion of his paper showed several Auer incandescent burners fed with hydrogen in place of coal gas, and stated that these burners would yield 672 candle-hours per kw. of electrical energy used in the production of the hydrogen, as compared with 666 candle-hours for the same energy used in the new Nernst glow-lamp.

Nernst, who joined in the discussion upon this paper, gave his reasons for doubting some of the statements made by the author. J. B. C. K.

539. *Electrolytic Oxygen and Hydrogen.* **Buffa.** (Assoc. Ing. Él. Liège, Bull. 11. pp. 305–344, Sept. 30, 1900.)—In this lengthy memoir the author discusses the industrial electrolysis of water under five sections, dealing with—Electrolytic Cells, Chemical Changes, Industrial Installations, Industrial Yields, and Applications, respectively. In Section I. he describes the cells of Renard, Garuti, and Del Proposto. The first used diaphragms of asbestos, the others metallic diaphragms which have proved more satisfactory. These are of thin sheet steel, it having been found that below pressures of 3 volts these sheets act as diaphragms, and not as secondary electrodes as one would have expected.

The electrolytic works at Rome, designed by Bossi and Bassani for the production of hydrogen for inflating military balloons, are described in Section III. These works are operated by alternating current at 2,000 volts from the generating station at Tivoli, 27 km. distant. This current is transformed in the works to direct current at 50 volts. The decomposing cells are 51 in number and are of the Garuti type. They are worked in three parallel series of seventeen each, each series taking 400 to 450 amperes at 45–50 volts. A 14 per cent. sodium hydrate solution is used with iron electrodes. A film of oil is employed to cover the surface of the electrolyte.

Section IV. deals with yields and costs, and it is stated that at Rome 1-h.p. hour measured at the terminals of the primary circuit of the transformer yields 0·086 c. metre hydrogen gas. At Brussels 1-h.p. hour measured at the terminals of the decomposing cell yields 0·12 c. metre hydrogen. At Rome the kw. year costs 96·6 frcs., and the cost of 1 c. metre of hydrogen and ½ c. metre of oxygen is 20 cents, interest and depreciation charges excluded. The cost of a 100-h.p. installation, with the necessary pumps for compressing the gases produced, is estimated at 110,000 frcs.

In Section V. the author discusses the various applications of the gases produced by the electrolysis of water. These are as follows: Soldering metals by the oxyhydrogen flame, soldering aluminium, soldering accumulator plates, repairing the tubes of water-tube boilers, soldering trolley wires, use of hydrogen for military purposes, use of oxygen for medical and surgical work, illumination by the oxyhydrogen light, heating by the oxyhydrogen blowpipe furnace, melting glass by the oxyhydrogen flame, and use of hydrogen in gas-motors. J. B. C. K.

540. *Electrolytic Regeneration of Chromic Acid Solutions and Manufacture of Diaphragms.* **M. Le Blanc.** (Zeitschr. Elektrochem. 7. pp. 290–295; Discussion, p. 295, Nov. 15, 1900. Paper read before the Deutsch. Elektrochem. Gesells. at Zürich, Aug., 1900.)—Acid solutions of sodium bichromate are much used in the organic chemical industry as oxidation reagents. The method generally adopted for regenerating these solutions after use is a chemical one, and is both troublesome and wasteful. .

Fitzgerald was the first to patent an electrolytic method for effecting this regeneration, but his process, patented in 1886, was unsatisfactory, and has given way to an improved electrolytic method now in use by the "Höchster Farbwerke." The spent chromic acid solution is placed in the anode and kathode chambers of a diaphragm cell. The anode liquid is oxidised, and gains in sulphuric acid; the kathode liquid loses in acidity, and hydrogen is liberated. After a definite interval of time the kathode liquid is transferred to the anode chamber of the cell, and more spent chromic acid solution is charged into the kathode division. The process is therefore a cyclic one, and no loss of acid or of chromium compounds occurs. A 70–90 per cent. oxidising current efficiency can be attained in the anode chamber, with an e.m.f. varying between 2·7 and 4·0 volts. Lead anodes are used, this metal giving better results than platinum. The only difficulty in connection with this process is in the manufacture of durable diaphragms of low electrical resistance. Without diaphragms the current efficiency of the cell sinks to only 10 per cent. at 15° C., and electrochemical methods of avoiding the necessity for diaphragms have proved unworkable in practice. The author describes at length the different steps by which the present method of manufacturing the diaphragms for the "Höchster Farbwerke" was evolved.

The composition used in their manufacture after firing at 1,000° C. contains 75 per cent. SiO_2 and 25 per cent. Al_2O_3. Plates measuring 720 × 970 × 7 mm. have been made from this mixture, which can also be worked up into cylinder form. These diaphragms have proved themselves to be remarkably resistant to chromic acid solutions, one diaphragm having been in use over one year without any visible deterioration. The electrical resistance of the diaphragms is small, the loss of pressure with a current of 200 amperes per sq. metre at 20° C. being only 0·15 to 0·20 volt. The German firm of Villeroy & Boch have taken up the trade manufacture of these diaphragms.

A short discussion followed the reading of this paper. J. B. C. K.

541. *Electrolytic Chlorate from Calcium Chloride Solutions.* **S. A. Tucker** and **H. R. Moody.** (Soc. Chem. Ind., Journ. 19. pp. 977–981, Nov., 1900. Paper read before the New York section of the Society, Oct. 19, 1900.)—The authors desired to find whether any industrial process could be devised for dealing with the large amount of calcium chloride obtained in solution as a by-product in the ammonia soda industry. The results obtained in the course of 67 experiments are given in tabular form, and the conclusions drawn from these experiments are summarised as follows: (1) The highest yields of chlorate are obtained with an electrolyte containing 20 per cent. calcium; (2) the electrodes should be of platinum, horizontal, and about 10 cm. apart; (3) the best current density to employ is one of 8 amperes per sq. dcm. measured at the anode; (4) the best results are obtained at a temperature of 80° C.; (5) the addition of sodium bichromate, or sodium hydrate, to the electrolyte increases the efficiency of the cell; (6) working under these conditions it is possible to obtain very high current efficiencies in the cell even with prolonged periods of working, the fall in efficiency during a run of 49 hours being equal to only 11 per cent. J. B. C. K.

542. *Progress of the Aluminium Industry.* **Héroult.** (Ind. Électrochim. 4. pp. 81–83, Aug., and 89–90, Sept., 1900. Reprint of a paper read before the "Congrés International des Mines et de la Métallurgie," 1900.)—The author gives some figures showing the increase of production and fall of price in this industry since 1886. The present output he estimates at 5,000 tons, and one-half of this he states is used in steel works. The use of aluminium for electrical conductors he believes to have a great future before it. In connection with the improvements in the process of extracting aluminium from alumina, he names Lontin, Grabau, Minet, Kleiner, Cowles Bros. and Hall, and then passes on to a detailed account of the experimental work which led up to his own process for aluminium manufacture. The chemical changes involved in the operation of this process are also fully dealt with. The paper concludes with a list of the works in Europe and America now producing the new metal, with the names of those responsible for their financial and technical management. J. B. C. K.

543. *Poulenc and Meslans' Apparatus for the Manufacture of Fluorine.* **Brochet.** (Électricien, 20. pp. 273–275, Nov. 3, 1900.)—This apparatus is based on Moissan's discovery that copper may be used in place of platinum for the construction of the electrolytic vessels and tubes for the production of fluorine [*cf.* Abstract No. 2072 (1900)]. The containing vessel is of copper, with a cover and tube to remove the hydrogen liberated; within is a rectangular copper vessel serving as an anode chamber, the walls of which at the lower part are perforated with V-shaped holes, so that it plays the *rôle* of a porous diaphragm. The anode consists of a long narrow copper-box covered on two sides with platinum plates. Connected metallically with the upper part of the anode chamber is a metallic tube for the removal of fluorine. The whole vessel is immersed in a freezing mixture, and a cooling liquid is constantly circulated through the hollow anodes. The anode chamber is insulated from the outer kathode vessel by a layer of caoutchouc, but this material in no place comes in contact with fluorine. The electrolyte is a solution of potassium fluoride in anhydrous hydrofluoric acid, and the contamination of the generated hydrogen and fluorine by hydrogen fluoride is prevented by passing these gases severally through tubes surrounded by freezing mixtures. Two forms of apparatus are described, one for industrial, the other for laboratory use. They form the subject of a patent, and were shown in the Paris Exhibition. W. G. M.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

544. *Relative Efficiency of Triple and Quadruple Expansion Engines.* **A. L. Mellanby.** (Mech. Eng. 6. pp. 764–769, Dec. 1, 1900. Paper read before the Manchester Association of Engineers, Nov. 24, 1900.)—The object of this paper is to show by actual trials the consumption of triple and quadruple expansion engines working under similar conditions, and to determine why one type should be more economical than the other.

The trials were made at the Durham College of Science, Newcastle-on-Tyne. The quadruple engines had cylinders 7″, 10½″, 15½″, and 23″ by 18″ stroke; the triple engine had cylinders 7″, 10½″, and 23″ by 18″ stroke, or 7″, 15½″, and 23″ by 18″ stroke. The power of the engine was absorbed by a Froude hydraulic brake.

The point of maximum economy with the quadruple engine was reached when the cut-off in the h.p. cylinder was about two-thirds and the total number of expansions about 17·4. In the triple engine the trials with the smaller m.p. cylinder gave the better results. The quadruple engines always consumed less water than the triple engines, but the triple engines gave a much higher mechanical efficiency than the quadruple set, and that through a much greater range.

Considerable changes in consumption could be effected by altering the cut-off in the m.p. cylinder while leaving the cut-off in the h.p. unchanged. As the pressure in the first receiver drops, the consumption of water rises. The reason for this increase is partly due to the smaller amount of cushioning there is in the h.p. cylinder, and therefore more steam is required to fill them. Initial condensation only accounts for a small proportion of this increase; the greater proportion of it is due to leakage past the valves, consequent on the greater difference of pressure. The back pressure of the h.p. cylinder should therefore be kept as high as possible. Up to the limiting pressure of the experiments, viz., 210 lbs. per square inch, there appears to be very little advantage in the quadruple over the triple engine, but the valve leak seems to have had considerable effect in the economy. L. S. R.

545. *Test of Allis Triple Expansion Pumping Engine.* (Eng. News, 44. pp. 125–126, Aug. 23, 1900.)—The engine is vertical, with triple expansion, running at 17½ r.p.m., and having a capacity of 30,000,000 U.S. gallons in twenty-four hours. The cylinders were all jacketed, and the receivers were fitted with reheating coils between the h.p. and i.p., and between the i.p. and l.p. cylinders. The arrangement of jackets and coils and the circulation of steam through them are fully described. The surface condenser has 2,000 square feet of cooling surface, and is fitted with an exhaust feed-water heater, having 300 square feet of heating surface between the l.p. exhaust and the condenser.

The contract was a duty of 150,000,000 ft. lbs. for each 1,000 lbs. of dry steam supplied to the engine. The cylinders are 30″, 56″, 87″ diameter and 66″ stroke. The diameter of the plungers is 42″. Grate surface of boiler, 63·87 square feet; heating surface, 2,849 square feet; ratio, 1 to 44·6.

Duration of trial	24 hrs.
Boiler pressure, mean	187·37 lbs.
Temperature of gases leaving boiler	485·4° Fahr.
„ „ „ economiser	221·9° „
Total i.h.p.	801·5
Average steam per i.h.p. per hr.	10·48 lbs.
Coal per hour per sq. ft. of grate surface	12·8 „
„ „ „ of heating surface	0·287 „
Evaporation per lb. of coal from and at 212°	12·47 „
Coal per i.h.p. hour	1·02 „
Duty per 1,000 lbs. steam (contract value 150,000,000 ft. lbs.)	176,051,500 ft. lbs.
Efficiency of mechanism	93·20 per cent.
„ „ boiler and economiser	85·9 „
„ „ „ alone	80·3 „
Thermal efficiency of engine	21·63 „

L. S. R.

546. *Liquid Fuel.* **E. L. Orde.** (Mech. Eng. 6. pp. 775–777, Dec. 1, 1900. Paper read before the North-East Coast Institution of Engineers and Shipbuilders.)—Recent increase in the number of places in the East at which crude oil can be obtained makes the use of liquid fuel an important question for ships trading to the eastward. Experiments were made by the author with crude Borneo oil of the composition:—Carbon, 87·9 per cent.; hydrogen, 10·78 per cent.; oxygen, 1·24 per cent.; flash-point, 211° Fahr.; boiling-point, 395° Fahr. Calorific value by bomb calorimeter, 18,831 B.T.U.

The various constituents of fuel oils give off vapour at temperatures varying from 100° Fahr. up to the boiling-point of the oil, near which point a residue of solid carbon is formed tending to choke up pipes or passages and to accumulate in the furnace.

The following methods of using liquid fuel are referred to:—(1) Injecting the oil under pressure through a nozzle as spray into the furnace. (2) Spraying the oil by means of air or steam under pressure. (3) Vaporising the oil.

The evaporative efficiency found by the author under the first plan was about 12 lbs. of water from and at 212° Fahr. per lb. of oil: a large excess of air and large furnace space were required for combustion. Under the second, 13 to 14 lbs. from and at 212° Fahr., less air being required. Under the third, with a plan of the author's, 15 to 16 lbs. from and at 212° Fahr., a minimum of air being required, and the waste gases showing the following composition:—

Analyses of Waste Gases.	I.		II.	
Carbon dioxide	13·2	per cent.	12·6	per cent.
Oxygen	3·6	„	4·0	„
Carbon monoxide	0·0	„	0·0	„
Hydrocarbons (Olefines, &c.)	0·0	„	0·0	„
Hydrogen	0·0	„	0·0	„
Nitrogen	83·2	„	83·4	„
	100·0		100·0	

The appearance of the flame at a few inches from the nozzle suggested that the hydrocarbons were burning in the form of acetylene.

The general conclusions arrived at by the author are :—(1) A reduction in consumption of fuel, with Borneo oil as compared with coal, of about 40 per cent. (2) A reduction in bunker space of about 15 per cent. for equal weights of fuel. (3) A reduction in the stoke-hold staff of at least 50 per cent.

The author recommends filtering the oil in all cases to prevent accumulation of dirt in the burning apparatus. F. J. R.

547. *Steam Engine Indicator Tester.* **C. A. Read.** (Mech. Eng. 6. pp. 832–833, Dec. 15, 1900. Paper read before the American Society of Mechanical Engineers, N.Y., Dec., 1900.)—A description of an arrangement of apparatus for the so-called dynamical testing of steam-engine indicators. The drum of the indicator is actuated by a cord attached to a lever on the three-way cock. The cock is rotated at any required speed, and puts the indicator into communication with two reservoirs alternately. The pressure in the reservoirs is determined by means of a [presumably dead-weight] gauge-tester. The two lines traced on the card should be horizontal and at a distance apart which represents the difference of the pressures in the reservoirs. H. R. C.

GAS AND OIL ENGINES.

548. *Engines for Blast Furnace Gas.* **A. Wagener.** (Zeitschr. Vereines Deutsch. Ing. 44. pp. 1517–1524, Nov. 10, and 1568–1572, Nov. 17, 1900.)—This paper describes various gas engines supplied to the Hoerder Bergwerks und Hüttenverein for use with blast furnace gas, and tests on them carried out by the author. The engines are of the Oechelhaeuser and Junkers type, giving one impulse every revolution. The cylinder has two pistons, working in opposite directions, off cranks on the main shaft. The in- and out-let ports are opened and closed by the pistons themselves. A double-acting compression pump drives mixture into the main cylinder from one side of its piston, and from the other drives air through the cylinder immediately after the exhaust is opened. The 600-h.p. engine, built by the Berlin-Anhaltische Maschinenbau Aktien Gesellschaft, has two cylinders, each 675 mm. in diameter. Its speed is 125 r.p.m., and its possible overload 20 per cent.

Analyses of the blast furnace gas over a period of sixteen days showed a mean composition in volumes per cent. of CO 31·2, H_2 2·0 and CO_2 9·1. The mean calorific value, as measured in Junker's calorimeter, varied from 950 to 990 calories per cubic metre of gas at 0° C. The volume-ratio of gas to air in the mixture which produced most complete combustion was found to be 4 : 3. The residual gas showed on analysis 0·7 per cent. CO as the only combustible. The limits of inflammability were reached with ratios of gas to air of 4 : 6 and 4 : 1·5. The consumption of gas by the above-mentioned 600-h.p. engine was slightly over 3 cubic metres per h.p. hour.

The preliminary trials made with other engines, and the means employed to overcome various defects, are described in detail. Scale drawings and illustrations of the engines are also included in the paper. G. H. B.

549. *Bánki Oil Engine.* **E. Meyer.** (Zeitschr. Vereines Deutsch. Ing. 44. pp. 1056–1063, Aug. 11, 1900.)—The Bánki engine in its 20 h.p. size, as illustrated in this paper, is of the vertical type, and draws oil into the cylinder in the form of a spray. Its essential difference from other motors of a similar

type is that water is drawn into the cylinder together with the charge of oil and air in order to cool the cylinder and permit the use of higher compression pressures. The following table gives the result of tests made on the engine :—

Horse-power	26·4	20·7	15·1	8·2
Kilos of benzine per h.p. hour	0·221	0·235	0·261	0·326
Ratio, weight of water to weight of benzine	4·84	3·30	2·82	2·33

Compression pressure, 16·4 kg. per sq. cm. ; explosion pressure, 38 kg. per sq. cm. ; ratio of total cylinder volume to compressed volume, 9·8.

The greater part of the paper consists of calculations, based on theoretical grounds, of the economy effected by the introduction of water. The author was not able to ascertain experimentally to what extent the water was gasified on its introduction into the hot cylinder and before compression ; he does not, however, think that the vaporisation can be complete. The calculations therefore are made for the two extreme cases, assuming no vaporisation of the water, and assuming its complete vaporisation. Again, since no exact figures are available giving the variation of specific heat of gases with the temperature at high temperatures, the calculations are made for two cases : firstly, assuming the specific heat constant, and secondly, taking Mallard and le Chatelier's figures, which the author considers give too great variations. The compression ratio possible with water-jet is taken as 9·6, and without as 4·0. The following are the results of the author's calculations :—Assuming the specific heat to be constant, the use of a water-jet increases the efficiency by 25 per cent. if the water be vaporised, and by 11 per cent. if liquid ; assuming the specific heat variable, it increases the efficiency by 28 per cent. if the water be vaporised and by 23 per cent. if liquid. G. H. B.

AUTOMOBILISM.[1]

550. *Novel Automobile Steam Engine.* (Horseless Age, 7. pp. 76–78, Nov. 7, 1900.)—The engine of A. J. Peet, of New York, is described, in which four single-acting vertical cylinders, two h.p. and two l.p., are arranged so that their connecting rods actuate a quadrilateral pyramid pivoted at the centre of its base. At the apex of the pyramid is fixed a pin, the projection of which fits into a bushed lug on a bevel pinion fixed to a vertical shaft. This pinion gears with a bevel wheel at the end of a horizontal shaft which replaces the crankshaft of the ordinary engine. The engine described is intended for a steam automobile and develops 4 h.p. It weighs 100 lbs., and the cylinder dimensions are 2⅛-inch and 4⅞-inch bore by 3¼-inch stroke. Diagram illustrations are given. C. R. D'E.

551. *French Automobile Trials.* **G. A. Burls.** (Automotor Journal, 5. pp. 80–81, Nov., 1900.)—The author summarises the results of the trials which took place at Vincennes in connection with the Paris Exhibition. The competing vehicles were divided into two classes, "light" and "heavy." In the former class the vehicles ran a total of about 190 miles through Paris on six consecutive days, and the heavy vehicles ran about 40 miles per day in two stages for a similar period. The light vehicles carried loads of from 2 cwt. to 5 cwt., and the heavy vehicles from 1 ton to 2 tons. Separate consumption trials over a level road for 12·9 miles furnished the results tabulated below :—

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[1] Electric Automobiles are described in the section dealing with Electric Traction.

Maker's Name.	Gross in Tons.	Average Speed m.p.h.	Gross Ton-Miles.	Consumption per g.t.m.		
				Petrol in Pints.	Coke in lbs.	Water in lbs.
Riker........................	2·76	9·18	35.6	—	—	—
Panhard lurry............	4·42	11·30	57·0	0·228	—	—
Panhard omnibus	4·53	9·25	58·5	0·455	—	—
De Dietrich................	4·23	10·37	54·7	0·242	—	—
Peugeot	2·36	9·50	30·4	0·289	—	—
De Dion lurry............	—	12·80	—	—	—	—
Turgan & Foy	4·83	13·70	62·3	—	2·12	11·6
Pantz	3·17	7·70	40·8	0·345	—	—

The author considers that the trials suffered from a lack of thoroughness of organisation, and that the results possess no great accuracy ; he also calls attention to the unwise tendency of the French drivers to run their heavy vehicles too fast. C. R. D'E.

552. *The Automobile Manufacturing Company's Steam Carriage.* (Automotor Journal, 5. pp. 107–111, Dec., 1900.)—This vehicle is fitted with a flash type of boiler, a furnace burning ordinary kerosene, an oscillating and double-acting engine which drives direct on to the rear axle, a condenser for saving part of the feed-water, and a reheater for rendering any uncondensed steam invisible. The whole system employed has many interesting and novel features ; these are fully described and are illustrated in detail in this article. An experimental car, which has already been built, is first dealt with, and this is followed by a description of a later design, which is now in course of construction. In the latter vehicle the boiler consists of eight coiled double tubes, into each of which the water is forced by a pump and by an automatic regulator. The boiler is fixed in the front of the car, and the steam is taken from each of the tubes through a common pipe to a distributing and reversing valve behind the back seat. The boiler is normally fed with kerosene, which passes through a vaporising coil above the boiler tubes. The feed of the fuel into the burner is controlled by a needle-valve, which regulates the size of a passage through an air-injecting nozzle. Petrol is used for first heating the boiler, and a spirit flame is employed for vaporising the petrol. The steam is led to and from the two cylinders, which are double-acting, and which have a bore of 4 inches and a stroke of 8 inches, through ports in the trunnions upon which they oscillate. A variable cut-off valve, of the mushroom type, is operated by a cam on the main shaft and can be regulated by hand. Reversing is effected by changing over the steam and exhaust connections to the trunnions. The exhaust steam passes through a large condenser underneath the centre of the car to a drum which is connected with the top of the water tank by a pipe ; a portion of this pipe is formed into a coil which is placed inside the water tank. Another pipe connects the top of this tank with a reheater above the boiler. The water is fed to the generator tubes by means of a force-pump which is always working when the engines are running. This pump has a constant delivery for any given speed, and it is of such a size that it always supplies more

water than is ever required. The water is forced into a cylinder in which a piston provided with springs resists the entrance of the water. The piston is connected with a by-pass valve in such a manner that it returns the water from the cylinder to the suction pipe of the pump as soon as it has been forced outwards a certain distance. The cylinder is in communication with the boiler tubes through a non-return valve, and as the boiler-pressure falls, water passes into the tubes automatically. The normal boiler-pressure can be regulated by adjusting the strength of the springs which act upon the piston. For starting the engines it is only necessary to draw the piston forward against the action of the springs and then to release it; a lever is fitted for this purpose, and can be worked by the driver when necessary.
A. G. N.

553. *Economy in Steam Vehicles.* **E. C. Oliver.** (Horseless Age, 7. pp. 15–17, Nov. 21, 1900.)—After pointing out the low efficiency of existing steam carriages and the expense of gasoline as fuel, the writer looks for improvement in the boiler, in the cylinder design, in the valve gear, and in the transmission mechanism. As there are so few tests of these small machines available, he draws the following conclusions from those made with larger boilers and engines. The relative evaporation of the three types of boiler, per lb. of fuel, are :—Water-tube 8 to 10, fire-tube (return flue) 6 to 8, and locomotive 5 to 6. The first of these is more economical and it is safer. Heating the feed-water, from the exhaust steam and from the waste products of combustion, enables a saving of fuel and a similar increase of boiler capacity to be made; a table giving the percentage of fuel used at various feed-water temperatures, the steam pressure being 70 lbs. per square inch, is given. The question of superheating the live steam is entered into, and a case is quoted in which 11 per cent. less feed-water resulted; the economy of superheating becomes less as the steam pressure is increased and as the cylinder lubrication becomes affected. The writer then discusses the use of steam-jackets round the cylinder and gives an instance in which, with steam at 50 lbs. pressure, considerable economy resulted. On the subject of steam distribution, the writer mentions that with the ordinary link-motion valve-gear a loss of from 15 to 30 per cent. over other methods results; he urges the necessity for a more perfect system for this type of engine. Compound and triple expansion engines are next dealt with, and their advantages are strongly insisted upon when high pressures are employed; the comparative economy over simple expansion is given as 20 per cent. with compound, and 30 per cent. with triple expansion. The convenience of being able to obtain an increased torque by admitting live steam to the lower pressure cylinders is also mentioned. Regarding transmission gearing, perfect alignment, rigid construction, correctly designed bearing surfaces and means for taking up wear are advocated. In summing up, the several sources from which economy may be expected are given in tabular form, and it is pointed out that, although some of these may not be applicable, there is ample field for a reasonable reduction of water consumption. It is possible, if desirable, to build a steam vehicle having a water consumption of 15 to 20 lbs. per h.p. hour; in such an outfit the engine and boiler should be closely related, the steam-pipe short and direct, the engine cross-compounded, both cylinders steam-jacketed with high-pressure steam, the burnt gases should reheat the steam for the low-pressure cylinder, and the feed-water should be heated by the exhaust steam.
A. G. N.

554. *Steam and Gas Engines on Automobiles.* **R. H. Thurston.** (Horseless Age, 7. pp. 40–42, Nov. 7, 1900.)—The main object of this article is said to be to indicate the relative advantages of steam and internal combustion engines for automobiles, but the bulk of the paper reiterates the well-known arguments in favour of automobiles generally and incidentally states that the opportunities for their use is not so great in America as in Great Britain because of the lower cost of railway work and of the greater cost of transit over the inferior roads. Concerning steam and gas engines, it is pointed out that both have undergone, and are still undergoing, radical improvement for this work; in the former, the prime difficulties lie in the safe control and storage of the fuel and in the change-speed transmission gearing; in the latter it is the boiler which is liable to give trouble. The use of the heavy, low-flash oils may yet be possible with internal combustion engines, and it is suggested that the other difficulty may be overcome by the use of a governor, or by the provision of steady pressure for starting. A boiler is wanted which will be safe at high pressures, which will supply any required amount of steam at a constant pressure, will be free from corrosion or incrustation, and will be efficient, light, and small. A. G. N.

555. *The Darracq Petrol Car.* (Locomotion Automobile, 7. pp. 770–774, Nov. 29, 1900.)—This machine is of the high-power voiturette type, and is of a very different design from those originally built by the same maker [see Abstract No. 566 (1900)]. The mechanism is mounted upon a tubular frame and is constructed in five separate parts, any of which can be removed independently by unscrewing four nuts; these parts are (1) the steering-gear, (2) the motor, (3) the radiator, (4) the change-speed gear, and (5) the differential gear and "live" rear axle. The motor is of the single-cylinder, water-jacketed, vertical type, and is placed in front; it develops 6½ h.p. and will run at any speed from 100 to 2,000 r.p.m. The output can be varied over a large range by means of a device which enables the driver to regulate the degree to which the admission valve can open; this adjustment allows of any lift of the valve between $\frac{1}{10}$ mm. and 4 mm. The motor is fixed with its crankshaft at right angles to the axles, and it is provided with a friction-clutch which connects it to a change-speed gear of the sliding toothed-wheel kind. The power is transmitted through a universally jointed shaft to a pair of bevel wheels, driving the rear axle. Three forward speeds and one reverse motion are provided for. The description of the vehicle is accompanied by drawings of the complete machine, of the underframe, of the motor, of the rear axle, and of the speed-gearing. A. G. N.

556. *La Métallurgique Voiturette.* (Locomotion Automobile, 7. pp. 786–788, Dec. 6, 1900.)—A well-illustrated description of a compact Belgian car. The chief features lie in the construction of the motor cylinders and in the arrangement of the whole transmission and differential gear inside a casing, which also forms the crank chamber. A rigid tubular underframe carries all the driving and steering mechanisms; the steering-heads for the front wheels and the bearings for the "live" rear axle are solid with it and the body is suspended upon it by springs. The motor with its gearing is mounted forward of the rear axle and centrally between the back wheels; their oil-tight case also encloses the differential gear on the driving axle. The 4½-h.p. motor is of the vertical double-cylinder type and its cranks are set at an angle of 180°. The valves and the electric-ignition device are of the usual type. The upper part of the cylinders are turned externally so as to taper slightly upwards, and a cylinder cover, which also contains the inlet and exhaust valves, fits over this tapered surface. That part of the cylinder-cover which fits over the cylinder is turned taper internally and is cut away between its upper and lower facing surfaces in such a way as to form a water-jacket between it and the cylinder wall. The cover is pulled downwards so as to make water-tight joints top and bottom by a screwed ring which fits against a thrust-taking surface on the cylinder wall, and which can be screwed upwards into the cover. That part of the cylinder head which contains the exhaust valve is also cored out to form a water-jacket. The flywheel is fixed outside the crank-chamber, and the crankshaft on that side of the motor is surrounded by a loose sleeve which passes between it and the bearing, and which connects an outside sliding-clutch face with an inside spur-wheel. The flywheel forms the other half of the clutch, and it can thus be coupled to the sleeve or disengaged from it. The spur-wheel on the sleeve meshes with a toothed wheel on a countershaft, which also carries three different sized spur-wheels. These three wheels remain always in mesh with corresponding wheels which are carried upon ball bearings concentric with the rear axle. These latter wheels are in reality merely rings with teeth on their peripheries, with ball races of large diameter on their sides, and with projections which act as clutches on their inner faces ; the central ring-wheel is held in place only by the balls between it and the other two rings. A sliding sleeve, which drives the differential gear, is mounted about the rear axle, and it is fitted with a disc which has projections on its outer edge and which can be moved into engagement with either of the three ring-wheels, thus giving either of three relative speeds to the driving wheels. A. G. N.

REFERENCES.

557. *Friction in Machines.* **N. Petroff.** (Acad. Sci. St. Pétersbourg, Mem. 10. pp. 1–84, 1900.)—Chiefly a theoretical investigation.

558. *American Central-valve Engine.* **E. T. Adams.** (Mech. Eng. 6. pp. 874–875, Dec. 22, 1900. Abstract of a paper read before the American Society of Mechanical Engineers, N.Y., Dec. 1900.)—A description of a central-valve engine similar to the Willans, but having the two cylinders side by side instead of tandem ; it is intended to run at only 200 to 300 r.p.m. H. R. C.

GENERAL ELECTRICAL ENGINEERING.

559. *Stretched Wires.* **R. Léon.** (Assoc. Ing. Él. Liège, Bull. 11. pp. 275–304, Sept. 30, 1900.)—The subject of sag and span of wires is considered theoretically. The overload (snow, &c.) per metre required to break the wire is worked out, taking the fall of temperature into account: longer spans will carry very slightly greater aggregate loads than shorter ones. For spans exceeding 200 metres, elasticity of the supports has very little effect. Various problems of wires on a line of posts are worked out. The paper makes free use of graphic diagrams. A. D.

560. *Electric Soldering of Zinc Pipes.* **Calmeau.** (Assoc. Ing. Él. Liège, Bull. 11. pp. 214–229, Aug. 14, 1900.)—The process of the electric welding of iron as it is now usually employed in England and America is first alluded to, and next those of Bernardos and Slavianoff, which are less known in this country and in which the heat of an electric arc is used to melt small pieces of iron which have been placed on the parts to be welded and covered with a suitable flux to prevent oxidation. This method may be extended to other metals than iron, and the author applies a form of it to the soldering of zinc pipes.

After enumerating the various inconveniences attendant on the use of ordinary soldering irons, he describes a new method of his own invention where the soldering iron is heated electrically, by which he avoids these defects. The implement consists essentially of an arrangement in which the usual copper portion of the soldering iron is surmounted by two sections or chambers one above the other, and insulated from one another by a partition of asbestos. The upper section carries a carbon pencil able to be raised and lowered by means of a screw cut on its holder, and is connected with the negative terminal of the source of the electric current, while the bottom of the lower section is formed by the copper portion of the soldering iron, which copper is connected with the positive terminal. The carbon pencil passes through the asbestos partition into the lower section, and being first brought into contact with a slight prominence on the copper and then slightly withdrawn, an electric arc is produced which heats the copper. Should the direction of the current be reversed by connecting the carbon with the positive terminal and the copper with the negative, the carbon and its surroundings become unduly heated, while the copper is scarcely heated at all.

The paper is illustrated by several drawings, and the mode of using the instrument is fully described, for which the original paper may be consulted with advantage. O. J. S.

561. *Electrically Controlled Pneumatic Street Clocks in Paris.* **G. Dary.** (Électricien, 20. pp. 340–342, Dec. 1, 1900.)—In the system employed by *La Compagnie Parisienne de l'air comprimé pour horloges pneumatiques*, the area to be served is divided into sections of 3 km. radius. In the centre of each of these sections is a substation to which the air-pipes of all the clocks extend. This substation is provided with a reservoir containing air at a pressure of 700 grammes per sq. cm. and with a slide-valve which, when in one extreme position, puts the reservoir into communication with the air-pipes or network of pipes connected to the secondary clocks, and when in the other extreme position, opens the network to the atmosphere. This slide-valve is actuated intermittently by a piston in a cylinder to which compressed air is admitted and exhausted through a slide-valve moved through a link from a pivoted armature arranged between the poles of two electromagnets. These electromagnets are energised intermittently every minute by means of currents from a commutator controlled by a master-clock at a central station, so as to move the armature first in one direction and afterwards in the other direction every minute. This system is in use in the 1st, 2nd, 3rd, 4th, 8th, 9th, and 10th arrondissements of Paris, and will shortly be extended to the left bank of the Seine. C. K. F.

562. *Electricity in Printing and Binding Works.* **W. H. Tapley.** (Cassier, 19. pp. 25-35, Nov., 1900.)—The power consumption in a printing office is reduced 40 per cent. by introducing electric driving, and the labour of handling is largely diminished. The first cost of electric driving is about £65 per press. The best motor is the "cumulative compound motor," controlled by armature resistance up to normal speed, and by the field control for higher speeds. The cumulative series winding provides a stiff starting torque. This is not necessary where the presses are constantly on long runs. The motors should have highest efficiency at 75 per cent. load, as this is their most frequent load. The cost of ungeared motors may be double the geared motor, but an advantage is obtained by their noiselessness, though it is a disadvantage that the motor armatures are not then interchangeable. The consumption of current on motors from 5 h.p. to 10 h.p. is the same whether the motors be geared or not; for smaller sizes the geared motor takes less power. The cost of upkeep of motor-driven machinery is less than when steam-driven, and this is diminished by circuit breakers which should always be used. No increased floor space should be taken by the motor, and the position of the controller must be studied for every new machine. The wiring should be in iron pipes, not only to protect the wires from mechanical injury, but from exposure to oil, printers' ink, and benzine. In binding, economy of power results from grouping sewing machines, wire stitchers, ruling machines, stabbing machines, folders, and case-making machines which require small motors from $\frac{1}{8}$ to 1 h.p. Nevertheless the increased output and minimised handling is worth the expense of individual driving. Heating the heads for embossing, stamping, glue, &c., by electricity has proved itself commercially superior to steam heating, with which the temperature cannot be controlled at all parts of the head. Any part of the head which is colder than another gives that part of the impression a lack of clearness. The heating of finishers' tools is more economically effected by gas. M. O'G.

563. *Electrical Heating of Metals.* **G. W. de Tunzelmann.** (Feilden, 3. pp. 387–400, Oct.; and 677–684, Dec., 1900.)—After giving some historical facts on this subject, and referring to Sir C. William Siemens' experiments in the early eighties, the author proceeds to enumerate more recent methods. Early attempts to use the arc struck between two carbons caused the deposition of a considerable quantity of carbon in the form of solid particles. In the fusion of iron and steel, this changes the character of the metal considerably, making it so hard that it is impossible to machine it afterwards; while in brazing and soldering it is difficult, and in some kinds of joints impossible,

on account of the deposition of soot, to get a clean joint. Methods introduced by the author for preventing this, led to "the Voltex process."

The method of applying electro-fusion to casting, and the causes of non-success are then discussed. The premature cooling of the upper surface of a steel casting, in the author's opinion, is the cause of faulty castings, and therefore any method which will keep the upper surface of the casting in a fluid state whilst the lower portion is solidifying, must produce sound castings free from both vacuous cavities and gas-bubbles. For this purpose the liquid metal surface is made to form the positive pole of an electric arc, of which a steel or carbon rod forms the negative pole. A mechanism is provided to raise and lower the rod forming the negative pole, so that the arc can be formed in the usual manner, and by moving the lid (shown in an illustration) the arc can be moved over the surface of the fluid metal. The object of this cover or lid is to prevent loss of heat by radiation. The thick iron walls of the mould have a thin metal prolongation lined with fire-brick, or similar resisting material; the fused metal does not stick to this, and since the fire-brick is an insulating material, no arc will be formed between the rod and the sides, and hence the latter will not be destroyed as might happen if no fire-brick were interposed. Experiments have shown that for the treatment of three blocks of crucible steel, each weighing about 6 tons, and one block of Martin steel of about 14 tons, a continuous current of 800 amperes at 60 to 70 volts is necessary. Calculations as to cost of production of steel by the above method show that Martin steel costs about 10 per cent. less and crucible steel 22 per cent. less than when made in the ordinary way.

Three processes in commercial use are then described in detail, namely, the Bernados process of electro-fusion, the Voltex process of electro-fusion welding, brazing, &c., and the Thomson process of electric welding. Data are given as to the amount of current used in these processes.

The author shows by calculations that the Voltex process of electric heating is far cheaper and more economical in many phases of manufacture and repairing than methods now in use. The disadvantages and difficulties of ordinary methods are claimed by the author to be in some cases partly, and in others entirely, obviated, by the new process. A case in point is in the brazing and filing up of a cycle frame, the cost of the old method by gas and coke being 5s. 9d., against 1s. 10½d. by the new one. The supposition that a great waste of current would be caused by passing the latter through a ring of metal, two ends of which are being welded together, does not hold good, as the long path of metal itself offers a greater resistance than the short path across the joint, and likewise the self-induction in the case of the alternating current causes only a small percentage of the current to take the longer path. According to the author, the larger apparatus used in the Voltex process might be employed by divers for cutting rapidly through large chain cables or iron plates under water, where the arc works perfectly well for this purpose, as it is not cooled down as much as might be expected by the water. The intense heat turns the water surrounding it into steam, so that the arc is insulated from the water by a cushion of vapour.

Very fine tools, taking carbons 7 mm. in diameter, are made for fine brazing and for jewellers' work, such as making the joints in rings. It should be of special value in working platinum, which melts readily or merely softens, according to the portion of the flame which is applied to it. Thus for many kinds of fine work, as applied to precious metals, it would be far more convenient than the methods at present in use. Similar instances of superiority are given, and comparisons as to time taken, which in most cases show striking reductions.

The article is well illustrated by photographs. O. J. S.

564. *Pile-driving Machines.* **F. J. Rowan.** (Inst. Engin. and Shipbuilders, Trans. 43. 4. Feb.; Discussion, 43. 5. March, 1900.)—After reviewing the various types of pile-driving engine which have been used, some of them from the earliest times, the author proceeds to sketch the attributes of the ideal pile-driving machine—lightness, speed of working, long range of fall, mobility, and cheapness. In an electrically driven machine designed by the author the weight is attached to a long, flat board, which is lifted vertically by the friction of two rollers, one on each side; disengagement is effected by moving one roller, the spindle of which is carried by an eccentric bush. As soon as the weight has fallen the roller is moved back so as to again nip the board and hoisting proceeds at once at full speed. The rollers are driven by an electro-motor which runs continuously in one direction.

Discussion.—**C. C. Lindsay** remarked that the connection between the driving rollers and the weight, whether it was flat timber or iron, would, when at its greatest height, offer so much surface to the wind that it would be practically unmanageable. He referred to the ordinary machine in which the weight is raised by a small steam winch as a survival of the fittest. **A. S. Biggart** suggested that the substitution of an electro-motor for the steam winch might be the best mode of application of electricity to pile-driving. The author in reply stated that the principal object of the clutch described was to have the blows follow one another rapidly. H. R. C.

REFERENCES.

565. *Electric Dock-cranes.* **L. J. Magee.** (Cassier, 18. pp. 267–281, Aug., 1900.) —A description of the electric cranes in various German harbours with illustrations (among others) of a solenoid brake and a double controller. In the latter the two motors for hoisting and slewing are controlled by one handle which actuates the two controllers through a universal joint; the two operations are thus readily performed simultaneously, the load following the direction of movement of the handle. H. R. C.

566. *Electric Travelling Cranes.* **C. W. Hill.** (Elect. Rev. 47. pp. 367–368, Sept. 7, 1900.)—The author first sketches the development of the electric traveller, and then gives a description, with diagrams, of a recently designed travelling crane for a load of 30 tons with a hoisting speed of 4 feet per minute, cross traverse 100 feet per minute, and longitudinal traverse 400 or 200 feet per minute. H. R. C.

567. *The Practical Value of Science.* **J. Perry.** (Inst. Elect. Engin., Journ. 30. pp. 43–68, Dec., 1900.)—Presidential Address to the Institution of Electrical Engineers.

GENERATORS, MOTORS, AND TRANSFORMERS.

568. *Effect of Armature Current on the Wave-Form of an Alternator.* **F. G. Baum.** (Elect. World and Engineer, 36. p. 1002, Dec. 29, 1900.)—The effect of the armature current on the wave form of an alternator is deduced graphically from elementary considerations. The case of an alternator which gives a sine curve of p.d. on open circuit is considered. When a current almost in phase with the e.m.f. is passing through the armature, then it is shown that owing to the reaction of the magnetising force produced by the armature current, the shape of the wave is no longer a sine curve. As compared with a sine curve it is raised on the ascending side and lowered on the descending side. The effective value, however, of the volts remains the same. When the current lags by about 90°, then it tends to demagnetise the field in all positions of the armature. We now get a peaked wave and the effective value of the voltage is lowered. When the current is about 90° in advance of the e.m.f. then the shape of the wave is flattened and the effective voltage is increased. The armature current in this case tends to magnetise the field in all positions, and if this reaction is great we get a symmetrical wave, the ordinates of which attain two "maximum" values in the half period.

A. R.

569. *Transformation of Alternating into Direct Current.* **P. Janet.** (Écl. Électr. 24. pp. 294–297, Aug. 25, 1900. Paper read before the International Electrical Congress at Paris.)—The author compares the four systems of changing alternating into direct currents. (1) *Electrolytic Rectifiers.* These depend on the property of aluminium electrodes, which allow no current to pass when forming the positive electrode in a cell; in an acid solution they will withstand a pressure of 20 volts, and in an alkaline solution of 140 volts, without letting current pass. Up to the present no practical use has been made of this property. (2) *Rectifiers*, consisting of an ordinary commutator driven by a synchronous motor. With large currents the sparking becomes prohibitive, and their extended use is not probable. (3) *Rotary converters* consisting of a synchronous motor and direct-current dynamo, combined to form one machine with a single armature-winding. There is saving of material over two machines, not only in the saving of one set of field magnets, but also in the copper on the armature. Comparing the output of a machine used as a direct-current dynamo and as a converter, the advantage is slightly with the former when the alternate current is single-phase, but the output as a converter increases with the number of phases, and with six-phase currents is about double the output when used as a dynamo. The efficiency of a converter is greater than that of a motor-generator, but, as it cannot be run directly off a high-tension circuit, the efficiency of the reducing transformer must in general be allowed for. (4) *Transformer-commutators.* These consist of a static transformer transforming a current of a small number of phases into one of many phases, and an ordinary commutator, which adds up the e.m.f.'s. of the different phases, as in a dynamo. To avoid sparking, the number of commutor sections, and consequently the number of phases, must be large; this entails either a large number of collecting rings on the commutator shaft, or revolving brushes with a fixed commutator. This system presents economy in material over a rotary converter, as a transformer is generally necessary in either case. Its efficiency also is high, as only a very small synchronous motor is required to turn the commutator. G. H. B.

570. *Design of Motors and other Apparatus for Intermittent Loads.* **E. Oelschläger.** (Elektrotechn. Zeitschr. 21. pp. 1058–1063, Dec. 20, 1900.)—Lifts may be taken as a type of electrical apparatus in which the load is intermittently applied for short periods. If a given maximum rise of temperature is desired under working conditions, it is not in general necessary to so design the motor that it would only attain this rise of temperature if worked continuously. Among other cases considered by the author, he takes the case of a resistance that would have a given rise of temperature if absorbing continuously 1 kw. His calculations show that if this same resistance were to absorb 8 kw. for half a minute, and were then switched off for five minutes, and this process were repeated indefinitely, its temperature would never at any time rise above that which it reached in the former case. The problem is dealt with both from the graphical and analytical points of view. The simplest case is that of the design of a resistance. The graphical method depends in the main on the preliminary construction of two curves, the one showing the rate at which the temperature increases under a given load, and the second the rate at which the temperature decreases when the load is thrown off. Supposing, then, that it is known how long the load is left on and how long it is thrown off, it is a simple matter to determine graphically the highest temperature reached, seeing that after the load has been switched on and off a few times the temperature goes through a well-defined cycle of variation. The designer would have to construct a variety of curves on the above lines, showing the rates at which wires of different gauges increased in temperature under various loads.

The analytical method depends on the determination, either by experiment or by calculation, of a quantity which the author calls the time-constant. The increase of temperature in a resistance follows a logarithmic law, and the time-constant may be defined as the time after which the rise of temperature is 0·688 times the maximum rise that is reached in the steady condition. It is therefore closely analogous to the time-constant in an inductive circuit. In considering the case of intermittent loads the author finally arrives at the equation—

$$\frac{a}{\mathrm{P}}=\frac{1}{1-\frac{\mathrm{T}}{a}\log\left\{p-e^{\frac{a}{\mathrm{T}}}(p-1)\right\}},$$

where a is the length of period of loading, P is the length of the period of loading plus the period of rest, T is the time-constant, and p is the ratio of the permissible overload to the load which could be taken continuously. Various simplifications of this equation under certain conditions are considered. In particular, it will be noticed that the equation becomes $p=\mathrm{P}/a$ if the ratio of a to T is small. In order to apply the equation it is necessary to know the value of T. The author shows how to calculate its value, and adds that Siemens and Halske have also experimentally ascertained it in various cases, the observations agreeing reasonably well with the calculations. The experiments gave the following values for the time-constant in the following cases, viz., for a 300-kw. transformer, 3·9 hours; for a polyphase motor of 85 h.p., 1·9 hours; for an enclosed direct-current generator of 9 kw., 6·5 hours; for a direct-current generator of 68 kw., 3·1 hours; for a resistance absorbing 2 kw., 30 minutes. In all these cases, supposing a to be 1 minute and P to be 3 minutes, then p becomes 3—*i.e.*, the permissible overload is three times the load that could be taken continuously. W. H. S.

571. *Theory of Synchronous Motor.* **E. E. Seefehlner.** (Zeitschr. Elektrotechn., Wien, 18. pp. 611–612, Dec. 16, 1900.)—As a result of the recent discussion on the theory of the general alternating-current transformer [see Abstract No. 266 (1901)], the author is led to introduce a modification into his treatment of the problem of a synchronous motor [Abstract No. 247 (1901)]. The modification consists in substituting v_1 (the armature leakage coefficient) for v_2 (the field coefficient) in the formulæ developed by the author. A. H.

REFERENCES.

572. *Designs for Small Single-phase Induction Motors.* **J. C. Brocksmith.** (Amer. Electn. 12. pp. 486–489, Oct.; 534–535, Nov.; and 572–574, Dec., 1900.)—Designs and working drawings are here given for the construction of small motors, respectively of ½ h.p., 1 h.p., and 2 h.p., working on 50 or 100 volts and 125 and 60 ∾. The motors are designed to be started by a phase splitting device. E. K. S.

573. *Requisites of Lighting Generator Sets.* **H. G. Reist.** (Elect. World and Engineer, 36. pp. 916–917, Dec. 15, 1900. Paper read before the U.S. Engine Builders' Association, Dec. 4, 1900.)—The author gives a table of suggested standard speeds of engines according to the power of generator, and discusses the effect of variations in speed when running alternators in parallel. H. R. C.

574. *General Alternating-Current Transformer.* **G. Ossanna, J. Heubach, B. A. Behrend, H. Grob,** and **F. Emde.** (Elektrotechn. Zeitschr. 21. pp. 1031–1033, Dec. 6; 1089–1090, Dec. 27, 1900; and 22. pp. 86–91, Jan. 24, 1901.)—Some further correspondence on this subject [see Abstracts Nos. 264, 265, 266 (1901)]. A. H.

575. 600-*H.P. Induction Motor.* (Elektrotechn. Zeitschr. 21. pp. 1087–1088, Dec. 27, 1900.)—A description of a 600-h.p. induction motor, running at 75 r.p.m. and a frequency of 22·5. The motor was constructed by the Maschinenfabrik Oerlikon, and is used for driving a pump in a German mine. A. H.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

576. *Alternators in Series for the Transmission of Power.* **M. Leblanc.** (Écl. Électr. 25. pp. 268–270, Nov. 17, 1900. Paper read before the International Electrical Congress at Paris.)—It is proposed to run induction machines as generators and to make use of the property they possess of running equally well in series as in parallel. The system suggested is analogous to that designed by Thury at Genoa, but the author will use alternating instead of direct current. The alternators will be compounded so that they will give a practically constant current at all loads. On short circuit the armature reaction will be so great that the current cannot exceed 10 amperes; hence there will be no risk from this cause. He proposes to adopt the exceedingly low frequency of eight periods per second. The advantages of this low frequency are numerous. The impedance of the line is very small, and there is practically no Kelvin effect. The dangers from resonance and the difficulties of insulation are very considerably lessened. Motors act also exceedingly well at low frequencies. At the receiving end of the line he will use his induction motors, which can have a power factor of unity. The lowering of the frequency gets rid of all the disadvantages of alternating currents whilst retaining all the advantages, such as the getting rid of commutators and saving the necessity of regulating both the generators and the motors. A. R.

577. *Condensers in Alternate-current Circuits.* **P. Boucherot.** (Écl. Électr. 24. pp. 297–302, Aug. 25, 1900. Paper read before the International Electrical Congress at Paris. Abstract in the Electrician, October 12, 1900.)—The author reviews shortly the various uses to which a condenser may be put in alternate-current work, especially in the case where a self-induction is connected in series and adjusted to resonance. A condenser may be connected in series with an inductive circuit to allow the passage of a larger current. It may be connected in shunt to diminish, as far as the generator is concerned, the magnetising currents of transformers and motors.

It may be used to obtain a constant current from a source of constant e.m.f. in either of the following ways:—(1) Connect a condenser and self-induction, adjusted to resonance, across the mains of constant e.m.f.; a circuit in shunt on the condenser or on the self-induction will have a constant current. (2) Connect two condensers and two self-inductions alternately in the four arms of a quadrilateral; if one diagonal be connected to constant e.m.f. mains, a circuit connected to the other diagonal will have constant current. Alternators may be excited off a condenser connected in series with a self-induction adjusted to resonance, so as to behave like a shunt-wound or series-wound direct-current dynamo, according as the condenser and self-induction are connected in series with, or in shunt to, the alternator, or the two connections may be combined to produce a compound excitation. The objections to the use of condensers are their high cost and their liability to produce very high potential differences on breaking the circuit. The author, however, considers that when a certain capacity is reached this effect will diminish. G. H. B.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

578. *Ringsend Power Station, Dublin.* **A. C. Shaw.** (Street Rly. Journ. 16. pp. 345–355, May, 1900.)—This article contains a very full description of the main power station of the Dublin United Tramway Company. The boiler-house is 76 feet by 131 feet, and contains 12 Babcock boilers, each having a heating surface of 2,530 square feet, fired by Vicars stokers. The top central portion of the boiler-house consists of a large bunker, capable of holding 1,500 tons of coal, the bunker being provided with chutes, which project down in front of the different boilers. The coal-handling machinery is described in some detail, and was provided by the C. W. Hunt Company, of New York. The coal is taken out of the barges by a steam-driven grab, having a capacity of about 1¼ tons; it is then deposited in a hopper, from which it is emptied into skips, which convey it to a large storage shed at the back of the boiler-house. It is finally taken by a form of bucket conveyer to the bunker above mentioned, which is placed above the boilers. The chimneys are of steel, and are two in number. They are lined with fire-brick, and have a height of 200 feet, and a diameter inside the brick lining of 10 feet. Each chimney is built of steel plates, tapering upwards and finishing with an ornamental cap at the top. The shell plates are lap-jointed and riveted, and vary from ⅜ inch to ¼ inch in thickness. The constructional details of the chimney are fully described. An economiser of 384 tubes has been installed. The engine-room, which is 153 feet by 80 feet, contains five Corliss engines by the Allis Company, each of which is direct coupled to a 500-kw. generator. They run at 90 r.p.m.; the cylinders are 20 inches and 40 inches in diameter, and the stroke is 48 inches; the crankshaft journals are 33 inches long; the flywheel is 19 feet in diameter, and weighs rather more than 30 tons. There are four negative boosters, giving outputs varying from 15 kw. to 24 kw. at 30 volts; they are motor-driven, and the voltage on the generator terminals is varied by means of a resistance connected in shunt with the series field. The travelling crane is designed for a load of 25 tons, with a lift of 26 feet; it is operated by three motors, series-wound, the motor for hoisting being rated at 20 h.p. The condensing plant consists of three Wheeler surface condensers, each having 2,400 square feet of heating surface. All the cables were supplied by the National Conduit and Cable Company, of New York. There are 18 feeders in all, varying from 0·2 square inch up to 0·75 square inch; the shortest is about 1,200 yards long, and the longest 3,490 yards. The cables are laid in wrought-iron pipes of an internal diameter of 3 inches. The manholes are about 450 feet apart, and vary in size according to the number of pipes leading into them, the largest being 10 feet square and 6 ft. 6 in. deep. There are also four return feeders, one composed of three cables, each having a sectional area of 0·538 square inch, and the other three consisting of two cables of 0·538 square inch. The article concludes with a brief description of the outside work on the track and overhead equipment. W. H. S.

579. *Electricity Works at Chèvres* (*Geneva*). (Elect. Rev. 47. pp. 586–591, Oct. 12; 665–668, Oct. 26; 708–709, Nov. 2; 772–773, Nov. 16; and pp. 912–913, Dec. 7, 1900.)—These articles deal with an important example of electrical distribution in the Canton of Geneva utilising the power of the river Rhône. The history of the hydraulic works is first detailed. The site of the new generating works is 600 m. up the river, and opposite the Chèvres Mill. In 1893 3,000,000 francs were voted by the Corporation for the first portion of the works, which was to include (1) the construction of the dividing dyke, the coffer dams on the left shore, and the dam ; (2) the construction of the coffer dam on the right shore, the turbine buildings, and the head and tail races ; (3) erection of the machinery and the laying of the feeders. The dam consists of one inverted arch foundation, two abutment piers, five intermediate piers having between them spaces for six gates with an opening of 10 m. The draining, which lasted nearly a year, was done by a Dumont pump and a pulsometer. The turbine building is 137 m. long, in which, during the year 1895, the first three sets of generators and two sets of exciters were installed. The generator sets each have a minimum output of 1,000 h.p., and comprise double turbine and alternator mounted on the same shaft. The exciter sets are similar, their output, however, being only 150 h.p. each.

According to the height of the river, the turbines had to work on the following conditions :—(1) In winter with a fall of 8·5 m. they had to work with an output of 1,200 h.p. with a volume of water as small as possible, yet at the maximum efficiency. (2) In summer with high water and using a net fall of 4·3 m. they were required to give 800 h.p. with an optional volume of water, and an efficiency of only 50 per cent. (3) To always maintain a speed of 80 r.p.m., without too large or too costly machinery. The scheme of Escher, Wyss & Co., of turbines arranged as stated above, was accepted. The shaft of massive steel 0·3 m. diameter is firmly supported by four bearings, and coupled direct to the alternator shaft, at the upper end of which is a ring bearing specially constructed for forced lubrication. Hydraulic regulating apparatus was adopted which was very effective ; for example, with a sudden variation of a load of 800 h.p. the speed was only reduced momentarily by 3 per cent., and when the full load was thrown off the variation was from 3 to 5 per cent., and in 4 to 5 seconds the governor had established normal speed. A description of the turbines, strainers, and admission gates is given. There are fifteen dynamos—Nos. 1–5 and 12–15—by the Compagnie de l'Industrie Électrique, Geneva, and Nos. 6–11 by Messrs. Brown Boveri & Co. Fourteen of the machines are two-phase alternators and the fifteenth is for direct current.

Machines 1–5, of 1,200 h.p., are of the Thury unipolar inductor type which have been designed of great strength, and with moderate self-induction. They are capable of being short-circuited without damage, and they run easily in parallel. The vertical shaft arrangement facilitates the repair of the machines, and the method of insulating the stationary armature and field magnets enables the insulation to be made very perfect. These alternators are 4·5 m. diameter and 2·2 m. high. The moving part is formed by a cover of cast steel, which consists of a double tooth crown, each with 34 radially placed teeth. The field magnet winding is formed of ribbon of copper insulated by rubber-treated canvas ; the armature winding consists of 34 bobbins of insulated cable. The machines will give either single or two-phase currents, the two systems of field magnets and armatures being arranged in such a manner that they can be easily displaced with respect to each other : the voltage is 2,750 at 45 ∿ . The electrical efficiency is 93 per cent. at full load. The total weight is 70 tons (French). The moving part on the shaft weighs 12 tons, the weight of the two turbines and their shaft is 12·05 tons, and the vertical pressure of water is 12 tons, so that the bearings of the dynamos have to support the load of 36·05 tons. This heavy weight has necessitated a special lubricated bearing.

Machines 6–11.—These are of a similar output to the previous ones, and the same periodicity, and are arranged to give 5,500 volts or 2,750 volts by the use of two independent windings which can be arranged in series or parallel.

The machines are of the "umbrella" type, with fixed armature, tunnel wound. The magnet, of umbrella shape, carries 46 pole-pieces and the exciting bobbins.

Machines 12–14.—These are, as before, of 1,200 h.p., but with a speed of 120 r.p.m. They supply two-phase current at 5,000 volts with 46 ∿. The armature is fixed and the field movable.

Machine 15.—This machine supplies continuous current for the electrochemical work of the Société la Volta at Chèvres. It is of the Thury type, and gives 4,000 amperes at 208 volts.

Switchboard.—There are small boards for each generator and one large general board for distribution. The board is 26 m. long with 34 panels. The high-tension parts are out of reach or behind the board. The high-tension switches are placed at the top of their respective panels, and are worked from a distance by means of a chain and toothed wheel. The chain works a second wheel keyed to a spindle which carries eight insulated contacts, which engage eight copper jaws; by this means eight breaks can be made, two in each conductor. The jaws are separated by thick slabs of slate. The fuses are behind the board in thick porcelain tubes which may be used as circuit breakers. The requirements of the system have rendered necessary the adoption of 2,750 volts for the underground lines, and 5,500 volts for overhead conductors.

Feeders (Underground).—From Chèvres to Geneva the distance is 5,825 m., and is divided into five sections, the ends being brought to substations. The method adopted is due to Graizier, chief electrical engineer. A concrete trough is used in which the four conductors are buried in "bitumen-concrete" and kept at a fixed distance of 0·5 m. from each other by special bricks. Bitumen-concrete is a mixture of bitumen, produced by the distillation of oil heated to 200° C., and small gravel well dried. In order to make it more plastic a certain proportion of vaseline is added. The concrete was run whilst hot into the trough immediately after the laying of the conductors. The whole is covered with a layer of concrete and with a cover of cement. Each conductor comprises seven copper cables, each of seven strands, of 3·6 mm. diameter. At the substations are the necessary transformers and switchboards. It was found that, in spite of precautions, occasionally foreign matter or water got into the bitumen, and this necessitated some repairs. At the end of 1899 the total length of feeders underground and overhead is 81,443 m., and the output 28,066,483 B.T.U. The principal users are the carbide and chemical manufacturers, various works, the tramways, and the lighting of the town and of many communes; also the waterworks, where a pump is in use capable of raising 380 litres per second 140 metres, coupled to to a 1,000-h.p. two-phase motor.

Tramways and Lighting.—The tramway system and part of the lighting is supplied by continuous currents, the alternating current being transformed by Alioth rotary converters. There are two converters for *lighting*, with a capacity of 100 kw. They have two independent windings and two commutators to supply the three-wire system, and four slip-rings for the two-phase side. Armatures are slotted and of Gramme type. The field magnets are of cast steel with 14 poles. The weight of each machine is 6,750 kg. Each commutator supplies 450 amperes at 110 volts running at 385 r.p.m. Transformers of 50 kw. per phase supply the converters at 70 volts. For excitation, 600 watts are necessary. The efficiency of machines is 90 per cent. For the *tramways* three 150-kw. converters are used. These have one commutator and four slip-rings. The armatures are of drum type, and give 560 volts and 268 amperes at 336 r.p.m. They are supplied by 80-kw. transformers at 360 volts. The frame is of cast iron, and the pole-pieces of cast steel. There are 16 poles. The total weight of each machine is 11,600 kg. The number of watts required for excitation is 1,150, and the efficiency 90 per cent. For starting the converters, the liquid resistances at first supplied have been replaced by 5-kw. regulating transformers in parallel with the secondaries of the main transformers.

Cost of Works.—This has amounted to £383,905, which includes £150,000 for turbines and dynamos, and £95,000 for feeders, transformers, and sub-stations.

A publication has been issued under the editorship of Turretini, minutely descriptive of this great undertaking. W. W. H. G.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

580. *Electric Haulage at the Eureka Mines, Windber, Penn.* **A. S. M'Allister.** (Amer. Electn. 12. pp. 317–321, July, 1900.)—This is an illustrated account of electric plant installed for the Eureka coal mines. Electric power is used for haulage by underground locomotives, compressed air being used for pumping and coal cutting. G.E. and Thompson-Ryan generators are used in parallel. Owing to the greater resistance of the series coils of the latter, the usual balancing wire connected inside the compound coils is in this case connected inside the compound coil of the G.E. machine and to a point part way along the series-winding of the Thompson-Ryan machine. This is stated to give good results. The method of controlling the motors (series-parallel) seems to be inapplicable for the work, and the troubles arising and suggestions for obviating are described. Ll. B. A.

581. *Electrolysis by Earth Returns at Peoria.* **A. B. Herrick.** (Street Rly. Journ. 16. pp. 996–1000, Dec., 1900.)—The author disputes the conclusions of D. H. Maury in his paper before the American Waterworks Association [see Abstract No. 2518 (1900)] that the bursting of the standpipe at Peoria was due to electrolytic corrosion. He contends that the material was inferior, and that many instances of similar "pitting" of cast iron, wrought iron, and steel structures were on record before electric traction was known. E. H. C.-H.

582. *Electric Conduit Railways.* **F. G. Cudworth.** (Street Rly. Journ. 16. pp. 1026–1029, Dec., 1900. Paper read before the Brooklyn Engineers' Club, Oct. 11, 1900.)—After reviewing the development of electric conduit systems from 1884 to 1900, the method of construction adopted in New York City is given in outline. In 1900 the Metropolitan Company of New York adopted the Falk cast-weld joint for repairing old 7-inch girder rails on the Lexington Avenue cable line, with the result that there was great improvement in the ease of riding. The cost of the cast joint was $4·25, including cleaning the rail with sand-blast and furnishing all necessary materials. The cost of excavating and relaying pavement around the joint was about $2·70, so that the total cost of the joint was little more than half the cost of new rails.

It is difficult to give an exact estimate of cost of underground conduit construction, but in New York City, where many pipes had to be removed and much repairing done, the cost per mile of single track was about $90,000, including feeders; in some cases it reached $150,000, and special work is enormously expensive. One double cross-over and two double-track turn-outs at 34th Street and East River cost $95,384.

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[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

E. H. C.-H.

583. *Economy of Welded Joints.* **K. Beyer.** (Street Rly. Journ. 16. pp. 1016–1017, Dec., 1900.)—Experiments on an important German tramway show that after six years' use the wear at the joint is on the average twice as great as on any point on the rail. Electric welding in the United States is dependent on the company controlling the patents, and enormously large apparatus is required. In the Goldschmidt method aluminium is used to secure high temperatures; and as but little apparatus is required, the cost per joint is lower. Calculations are given from which the author concludes that, taking all things into consideration, the welded joint is 20 per cent. more efficient than the fish-plate joint. E. H. C.-H.

584. *Contact Rails on the Manhattan Elevated Railway.* (Street Rly. Rev. 10. p. 708, Dec., 1900.)—Drawings are given of the contact rails, joints, and insulators which are being installed on this railway. The rails are 6 inches high, of T-section, weighing 100 lbs. per yard, and contain carbon 0·078 per cent., manganese 0·340 per cent., sulphur 0·073 per cent., phosphorus 0·069 per cent. The rails are each 60 feet long, and are erected in sections of 300 feet; they are anchored at the middle, but free to slide in insulator clips elsewhere. The insulator blocks are of artificial granite, placed every 9 feet. The joints between the 60-feet rails in each section are made with two-bolt fish-plates and four solid copper bonds, hydraulically riveted into $\frac{7}{8}$-inch holes, two in the web under the fish-plates and two in the bottom flanges. Each bond has a sectional area of 0·344 square inch. The 300-feet sections are joined by fish-plates having a slot at one end, and by four 18-inch, curved, stranded copper bonds, with rope-laid strands of wire not larger than No. 4 B & S, the sectional area of each bond being 0·353 square inch. All these bonds are riveted in the bottom flanges. The distance between the 300-feet sections to allow for expansion is determined from a table: if the rail is laid at 0° F., the gap is 3 inches, at 60° it is 1½ inches, and at 120° it is nothing.

E. H. C.-H.

585. *Double-truck Cars.* **N. H. Heft.** (Street Rly. Rev. 10. pp. 650–651; Discussion, pp. 651–656, Nov., 1900. Paper read before the Amer. Street Rly. Assoc., Kansas, Oct., 1900.)—Cars cannot be constructed and equipped so as to operate with equal economy under all the varying conditions of different tramway systems. Tramway trucks have hitherto been constructed on the lines of single-horse trucks. The author considers that steam railway lines should rather be followed. After experience with heavy and light motors, mounted with two motors on one truck, the other truck being an idle or trail truck, as well as with one motor on each truck, the author has found that, while greater efficiency is shown with the latter method, the two motors mounted on one truck show a saving in labour, first cost of the trail truck, and cost of maintenance. Maximum efficiency, with minimum cost of maintenance, with both heavy and light motors, has been obtained by mounting two motors on each truck, making a four-motor equipment. With

this form of equipment, higher speed and quicker acceleration are obtained with lower power consumption, both in the average and total for the whole trip. Controllers have not developed as rapidly as motors. The four-motor controllers in their present form are cumbersome, and it is more satisfactory to use a small pilot controller on the platform with some developed form of main controller underneath the car body. The author's double-truck car on the lines of steam railway trucks has weights as follows: Trucks, 3,970 lbs. each, four motors 2,385 lbs. each, car body and equipment, 12,300 lbs.; a total weight of 29,780 lbs. This amount divided by 63 passengers gives a dead weight of 473 lbs. per passenger. The cars of to-day show a dead weight of 750 lbs. to 1,100 lbs. per passenger.

Discussion.—Great difference of opinion was expressed amongst the speakers as to the economy of power with four-motor equipments, but all agreed that the absence of slipping wheels, the quicker acceleration and the consequent higher schedule-speed compensate for the increase (if any) in power consumed; also that it is considerably cheaper to maintain four motors under a car than it is to maintain two motors under the same car, and this difference in cost of maintenance more than offsets the interest on the extra capital cost. E. H. C.-H.

586. *Competitive Tests of Street Car Brakes.* (Street Rly. Rev. 10. pp. 462–464, Aug., 1900.)—In 1899 the Board of Railroad Commissioners of New York invited makers to submit their brakes for competitive tests, which were made with the utmost care with special instruments for graphically recording the speed and distance traversed. Tests were made only when the rails were dry, and all on 2,750 feet of street, having a total fall of 8·8 feet. Tests were made without sand at 8, 12, 15, and 16 m.p.h., and also with sand at 16 m.p.h. The results are shown in Tables I. and II.

TABLE I.

SHOWING AVERAGE STOPS MADE WITH ALL BRAKES TESTED AT 8, 12, 15 AND 16 MILES PER HOUR, AND AT 16 MILES PER HOUR WITH SAND.

NAME OF BRAKE.	8 MILES PER HOUR.		12 MILES PER HOUR.		15 MILES PER HOUR.		16 MILES PER HOUR.		16 MILES PER HOUR, WITH SAND.	
	Feet.	Secs.	Feet.	Secs.	Feet.	Secs.	Feet.	Secs,	Feet.	Secs.
Peckham Motor, Truck and Wheel Company	42·41	7·03	59·52	6·44	70·50	6·87	81·25	7·43	79·91	7·51
Devlin Street Car Brake Co.	54·08	7·38	65·80	8·86	92·36	9·58	93·63	9·51	84·91	7·98
Christensen Air Brake Co.	56·86	6·20	88·25	7·88	113·80	8·60	130·75	9·74	93·70	6·63
Standard Air Brake Company	54·19	5·79	76·08	5·48	86·83	7·32	104·47	8·48	93·04	6·58
General Electric Company	45·00	5·34	111·02	8·95	114·86	8·32	134·72	8·62	116·66	6·58
Columbia Car Light & Brake Co.	65·86	6·16	99·94	5·46	139·50	7·30	155·08	7·70	203·66	7·55
Sauvage Street Car Brake Co.	46·11	4·00	78·58	5·67	129·16	8·50	138·27	8·60	143·25	7·31
J. G. Brill Company	35·11	3·16	67.83	6·12	121·88	7·50	108·44	6·22	127·16	7·47
Safety Appliance Company	40·27	3·15	68·86	4·54	135·11	5·92	140·69	6·07	†	†
Vogel Brake Company	50·86	7·56	72·83	7·86	92·11	9·62	119·94	10·56	106·58	9·35
G. P. Magann Air Brake Co.	42·72	6·75	56·80	7·33	81·80	9·12	95·66	9·17	89·16	8·70
Price-Darling Company	45·27	7·23	—	—	—	—	—	—	—	—
Sterling Supply & Manufg. Co.	41·50	6·99	57·00	7·91	75·27	9·59	81·41	9·35	90·66	9·45
Electric Selector and Signal Co.	38·75	7·71	50·00	7·95	60·02	8·28	72·33	9·35	73·08	8·92
Bach & Schlegel	—	—	—	—	—	—	—	—	—	—
J. E. Reyburn	66·80	7·17	94·00	8·55	—	—	—	—	—	—

TABLE II.

SHOWING STANDING OF BRAKES BASED ON THE FORMULA AND PER CENT. OF RATING BASED ON THE AVERAGE STOPS, ALSO PER CENT. DEDUCTED FROM THIS STANDING FOR SKIDDING OF WHEELS AND THE PER CENT. OF RATING AFTER MAKING THIS DEDUCTION.

NAME OF COMPANY.	Formula * $\frac{w s^2}{d}$	Average stop at all speeds, Feet.	Per cent. of rating based on average stop.	Per cent. deducted for skidding of wheels.	Per cent. of rating after deduction.
Electric Selector and Signal Co....	66,197	58·83	100·00	1·7375	98·26
Sterling Supply & Manufacturing Company	58,073	69·16	87·73	0·875	86·86
Peckham Motor, Truck and Wheel Company	64,410	66·71	97·30	10·70	86·60
G. P. Magann Air Brake Company	54,853	73·22	82·86	4·00	78·86
Devlin Street Car Brake Company	54,424	78·15	82·21	6·20	76·01
Standard Air Brake Company......	49,907	82·92	75·39	5·75	69·64
General Electric Company	45,630	104·45	68·93	0·225	68·71
Vogel Brake Company	44,300	88·46	66·92	0·875	66·05
Christensen Air Brake Company...	44,322	96·67	66·95	2·00	64·95
J. G. Brill Brake Company	44,545	92·08	67·29	4·35	62·94
Safety Appliance Company	38,290	96·10	57·84	1·0625	56·78
Sauvage Brake Company	36,600	107·07	55.29	0·6875	54·60
Price, Darling & Company	31,803	45·27	48·04	0·1875	47·85
J. G. Reyburn Brake	29,547	80·40	44·63	0·25	44·38
Columbia Car, Light & Brake Co.	29,325	132·80	44·30	0·225	44·08
Bach & Schlegel (no test)............	—	—	—	—	—

Per cent. deducted for skidding wheels is based on the following values :—

Skidding 15 feet or more.		Skidding 10 feet to 15 feet.		Skidding 5 feet to 10 feet.	
One large wheel	0·25	One large wheel	0·125	One large wheel	0·0625
One small wheel	0·125	One small wheel	0·0625	One small wheel	0·05125
Large and small wheels	0·45	Large and small wheels	0·225	Large and small wheels	0·1125
All wheels	1·00	All wheels	0·75	All wheels	0·50

Tests were also made with one type of brake on a wet rail, the average stop being 71·7 feet as against 60 feet on a dry rail. After adding or deducting points of merit or demerit for the following features : Reliability and simplicity of system ; liability of brakes to act when they should not ; ease of operation by ordinary motormen ; cost of equipment and maintenance ;—the order of merit was :—(i) Electric Selector and Signal Co. (ii) Peckham Truck Co. (iii) Sterling Electric Co. (iv) Magann Air Brake Co. (v) M. H. Vogel. (vi) Devlin Street Car Co. (vii) J. G. Brill & Co.

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* w = Number of passengers × 140 + weight of car 20,816 pounds, except the General Electric car, which weighed 24,000 pounds.

s^2 = The average initial speed squared.

d = The average stop at all speeds

(viii) Sauvage Street Car Brake Co. (ix) Standard Air Brake Co. (x) Christensen Engineering Co. (xi) General Electric Co. (xii) J. E. Reyburn. (xiii) Columbia Car and Brake Co. (xiv) Price, Darling & Co. (xv) Safety Appliance Co. (xvi) Bach & Schlegel. E. H. C.-H.

587. *Solution of the Electric Vehicle Problem.* **Luxenberg.** (Centralblatt f. Accumulatoren- u. Elementenk. 1. pp. 360–364, Nov. 1; and 380–385, Nov. 15, 1900.)—A previous writer in this paper has shown that the only practical methods of making electric vehicles more economical were (i) by reducing the weight of the vehicle itself by careful construction and choice of materials; (ii) by reducing bearing friction by use of roller bearings; (iii) by reducing the resistance due to rolling friction at the wheel rims by increasing the wheel diameters. The author enlarges on these points. A possible saving of 4 per cent. of the total weight of the vehicle and 4 per cent. in power is all that can be effected by the first method. By roller bearings the total weight may perhaps be reduced by 6 per cent., as the power required is 16 per cent. less. The third method is the only one which promises any great improvement. The coefficient of resistance of the rolling friction of the wheels against the ground is given by the formula $\tan \alpha = f/r$, where $f =$ the coefficient of the rolling friction dependent on the nature of the surface, $r =$ radius of the wheels, $\alpha =$ angle of slope on which the car keeps up constant speed without power, or without brakes on. If $K =$ tractive force on the vehicle, whose weight is $G = mg$, then—

$$K = G . \tan \alpha = G \frac{f}{r} = m . \frac{f}{r} . g,$$

and since (force × distance) = work, the work done is—

$$A = \frac{G . f . L}{r} = \frac{m . f . L . g}{r}, \text{ where } L = \text{distance.}$$

Thus K and A are inversely proportional to the wheel's radius; or we may state that the energy required to move a wheel round through a given angle is independent of the size of wheel, or that the work required for one revolution is independent of the size of the wheel. The same law holds for friction in bearings, because the larger the wheel the fewer the revolutions required to cover a given distance. For the same weight, and for the same distance on the level, tractive force, and energy required, are inversely proportional to the wheel radii; the distances covered with the same expenditure of energy are directly as the wheel radii.

The effect of increasing the wheel diameter and thereby proportionately lessening the coefficient of resistance is then considered. An electrical vehicle with wheels 100 cm. in diameter has a resistance on average roads of 3 per cent. of its complete weight. Allowing for the losses between the accumulators and the wheels, the work required per ton-kilometer is $\frac{3}{100} . 1000 . 1000$ kgm.-meters = 82 watt-hours. Hence, with a 44-cell battery, giving 82 volts, one ampere-hour per ton-km. would be required.

If the car has to go 80 km. with one charge at 16 km. per hour, then the discharge must be 80 ampere-hours for 5 hours per ton of total weight. Such a Planté battery weighs not more than 500 kg., *i.e.*, half the weight of the loaded car. If $g' =$ weight of loaded car, exclusive of battery, $g'' =$ the weight of battery, $G = g' + g''$, $D =$ mean wheel diameter in cm.,

$\tan \alpha =$ the coefficient of resistance expressed as a percentage of the weight, then—

$$\frac{g''}{G} = \frac{g''}{g' + g''} = \frac{50}{D}$$

whence—

$$g'' = g' \frac{50}{D - 50} \qquad (a)$$

but—

$$G = g' + g''$$

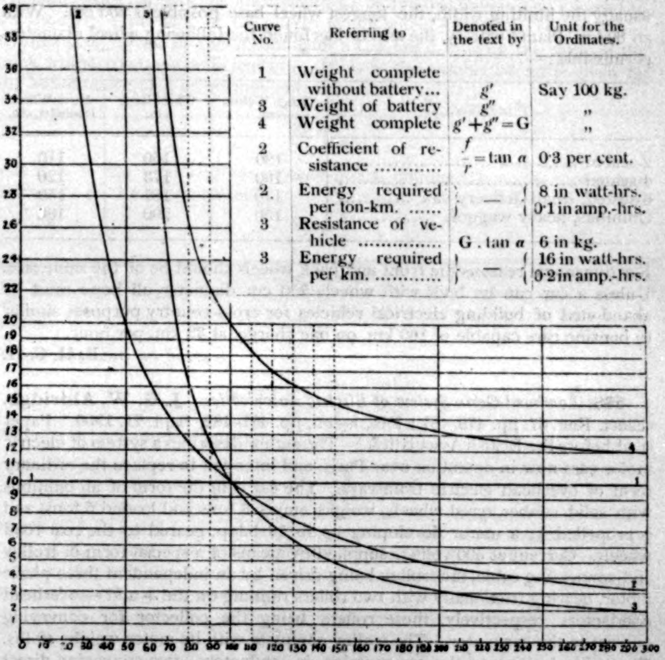
$$\therefore G = g' \frac{D}{D - 50} \qquad (b)$$

And—

$$\tan \alpha = \frac{300}{D}$$

$$\therefore G \,.\, \tan \alpha = g' \frac{300}{D - 50}.$$

In equations (*a*) and (*b*), since g' is independent of the size of wheel, the only variable factor in equations (*a*) and (*b*) is $1/(D - 50)$. We can thus plot the



Curve No.	Referring to	Denoted in the text by	Unit for the Ordinates.
1	Weight complete without battery...	g'	Say 100 kg.
3	Weight of battery	g''	„
4	Weight complete	$g' + g'' = G$	„
2	Coefficient of resistance	$\frac{f}{r} = \tan \alpha$	0·3 per cent.
2	Energy required per ton-km.	—	8 in watt-hrs. 0·1 in amp.-hrs.
3	Resistance of vehicle	$G \,.\, \tan \alpha$	6 in kg.
3	Energy required per km.	—	16 in watt-hrs. 0·2 in amp.-hrs.

(Mean diameter of the wheels in cm.)

curve in the adjoining Figure, which clearly shows the influence of the size of wheels on the weight and energy required, the vehicle being supposed to weigh 1,000 kg. without battery, and apparently to go 80 km. with one charge. With

50 cm. wheels, 80 km. is impracticable. By decreasing the wheels 20 per cent. from 100 cm. diameter (carriage size) to 80 cm. (pony size), the size and output of the battery, and therefore its maintenance, increase by 63·6 per cent. By increasing from carriage size to freight-waggon size (120 cm.), a corresponding decrease of 29 per cent. is made; or if to omnibus-back-wheel size (150 cm.), the decrease is 50 per cent.

In snowy weather the resistance rises to perhaps four-thirds of the normal. It is best to choose batteries for a normal four- or five-hour performance, *i.e.*, for 60 to 80 km., and having the highest possible capacity and shortest possible charging-time. Small capacity and light battery with a long charging-time should be avoided. Experience in America, London, and Paris confirms this.

Difficulties in construction arise if the steering wheels are large. To make room for the wheels the battery must be moved back, and this tends to make the car unmanageable on slippery roads, unless it is made longer and broader. Experience has shown that, to prevent the car rotating about a vertical axis through its centre of gravity on curves, at 16 km. per hour, the wheel base must not exceed four-thirds of the width between wheels. Since 150 cm. is usually the limiting width, the longest wheel base possible is 200 cm. With an 80-km. Planté battery, the author has found the following wheel diameters permissible :—

Type of Car.	Gauge Width, cm.	Wheel Base, cm.	Mean Wheel Diameter, cm.
2-seated	120	160	110
4-seated	130	173	120
6-seated, small delivery van	140	187	150
Omnibus, heavy waggon	150	200	180

For dynamical reasons the front and back wheels should be of the same size. Unless a car can be built with wheels 250 cm. diameter, all hope must be abandoned of building electrical vehicles for cross-country purposes similar to benzine cars capable of 160 km. on one charge, at 32 km. per hour.

E. H. C.-H.

588. *Lombard-Gerin System of Electric Automobiles.* **J. G. W. Aldridge.** (Elect. Rev. 47. pp. 479–481; Discussion, pp. 481–482, Sept. 21, 1900. Paper read before the British Association.)—The author describes a system of electric motor cars now in operation near Paris, and intended to replace the ordinary form of overhead electric tramways. The car is in the form of an omnibus with solid rubber tyred wheels, weighs empty 3 tons and loaded 5 tons, and is propelled by a motor developing up to 15 b.h.p. geared to the rear road wheels. Current at 500 volts is supplied by means of a special form of trolley and connecting cable, the trolley being driven by an independent three-phase motor, gearing frictionally with two rollers running on the + and — overhead conductors respectively, these rollers being the collector for conveying current to the car motor. The trolley complete with its motor weighs 40 lbs. The cable leading to the car contains six conductors—two conveying direct current to the car motor, three conveying three-phase current back to the trolley motor, and one for actuating an electromagnetic brake on the trolley motor. A special feature is the neat and inconspicuous arrangement of the trolley wires, which are suspended from short arms on poles at the side of the road,

When two cars going in opposite directions meet at a stopping-place the trolley cables have to be exchanged ; this is a simple operation, but for town traffic it is preferable to have trolley wires at either side of the road, so that the up and down traffics are quite independent. Several photographs of the line and trolley are given [see also Abstract No. 1880 (1900)].

C. R. D'E.

589. *Calculations for Automobiles.* **W. Kummer.** (Elektrotechn. Zeitschr. 21. pp. 846–847, May 3, 1900.)—By elementary methods the author deduces relations between the constants of the "accumulator," of the whole automobile and of the track, whereby all questions as to construction and use of automobiles can be theoretically answered. The calculations are applicable to all kinds of automobiles other than those which take in energy from an external source while moving. By "accumulator" the author denotes the body which contains the store of energy. Let P be the weight in kg. of the complete automobile ; p, that of the accumulator, whose "output-coefficient" in watts per kg. is K_L and whose "energy-coefficient" in watt-hours per kgm. is K_A ; v, the speed in km. per hour ; T, the time in hours of a complete discharge of the accumulators ; N, the distance in km. covered in the time T ; η, the ratio of the energy at the wheel rims to the energy at the terminals, or valves, of the accumulator ; $s, = \tan \alpha$, α being the slope of the track whose traction-coefficient is f. If L is the number of watts given by the accumulator at a given moment, then—

$$K_L = \frac{L}{p} \qquad (1)$$

and if A is the total number of watt-hours obtained from one complete discharge of the accumulator—

$$K_A = \frac{A}{p} \qquad (2)$$

Also—

$$T = \frac{A}{L} = \frac{K_A}{K_L} \qquad (3)$$

and—

$$T = \frac{N}{v} \qquad (4)$$

At any moment, we have—

$$L = P . v . \frac{f + s}{\eta} . \frac{9810}{3600} \qquad (5)$$

Whence by substitution and transposing we get—

$$PN = p . K_A . \frac{\eta}{f + s} . 0{\cdot}367 \qquad (I.)$$

where $(f + s)$, v and L are assumed constant over the whole distance N.

If p, K_A, η and $(f + s)$ are constant, equation I. determines the relation between the variables P and N. Under these conditions the speed is found by equating (3) and (4), whence—

$$v = N . \frac{K_L}{K_A} \qquad (II.)$$

where—

$$K_L = f(K_A) \qquad (III.)$$

These equations, I., II., and III., enable us to solve two general propositions : (i) What accumulator must be employed in order to move a given automobile at a given speed over a given track with a given load? (ii) What automobile must be employed in order that a given accumulator may move it at a given speed over a given track?

In the second case of the electric automobile, we have—

$$K_A . (K_L)^n = c \qquad \text{(III.}a\text{)}$$

where n and c are constants, n lying between ¼ and ⅔. As an example, an empirical curve connecting K_A and K_L is given for a modern French electric automobile, in which $p = 750$ kg., $P = 2{,}250$ kg., $\eta = 0{\cdot}70$, and $(f+s) = 0{\cdot}025$. When K_L is 2 and K_A is 16, N is 55 and v is 7, but when K_L is 10 and K_A is 10, N is only 38 though v is 35.

By considering a varying gradient as made up of sections over each of which $(f+s)$ is constant, the above formulæ can be applied to cases where $(f+s)$ is not constant by dividing the route into small sections over each of which it is constant. E. H. C.-H.

590. *Postel-Vinay Electric Waggon.* (Automotor Journal, 5. pp. 114–115, Dec., 1900.)—This vehicle is at work in Paris carrying loads up to 10 tons, and its total weight loaded is 22 tons. Its normal run is about 21 miles at 5 miles per hour. The batteries are of the "Phénix" type, weighing about 1¾ tons, or with the containing box in which they are placed under the centre of the frame, about 2½ tons. Two motors of the four-pole type with slotted drum armature are used, each capable of generating 10 b.h.p. normally, or up to 30 b.h.p. for a few minutes. They each weigh about 1,000 lbs. and run at a normal speed of 800 r.p.m. The speed control is on the series-parallel system. The steering wheels are separately pivoted, and are steered by an auxiliary 3 h.p. electric motor. A magnetic brake is provided in addition to mechanical rim brakes. Very complete drawings are given showing the details of the under-carriage and running gear. E. J. W.

591. *Wade Electric Controller for Automobiles.* (Automotor Journal, 5. pp. 139–140, Dec., 1900.)—This article relates to a car built by the Electric Motive Power Company, but is almost entirely occupied with a description of the controlling system employed. The various speeds are obtained by coupling the cells in six, four, three, and two parallels, and the speciality consists in so arranging the controller connections that a passage from one speed to another can be effected without breaking the motor circuit, thus eliminating sparking at the contacts and jarring of the car. This is accomplished by introducing between the working combinations, intermediate "pass-over" combinations in which some portion of the battery is always in circuit. Diagrams are given showing the grouping for each combination and the connections to the controllor. E. J. W.

ELECTRIC LAMPS AND LIGHTING.

592. *Street Lighting at Grand Rapids, Michigan.* **G. A. Damon.** (Amer. Electn. 12. pp. 459–464, Oct., 1900.)—The plant cost $180,000; the 500 lamps used are direct-current enclosed arcs, taking 6·5 amperes at 70 volts. The population is about 100,000, and there are 288 miles of streets. Forty very high towers of open ironwork support four lamps each; forty of the lamps are suspended on ornamental poles of wood and iron, and the rest are hung from cross-suspensions. Fletcher automatic suspension pulleys are used. In

the generating station there are six 150-light dynamos belted to three engines. The dynamos are of the Brush multi-circuit type, rated at 10,500 volts and 6·5 amperes when running at 500 r.p.m. Each machine has two separate circuits, so that the line voltage may be kept down to half the maximum. The two circuits are controlled by one regulator at the dynamo. The range of regulation is sufficient for 175 lamps. The engines are Russel horizontal tandem-compound, used with a Wainwright surface condenser. There are four 150-h.p. Cahall horizontal water-tube boilers, with a Green economiser. The stack is of steel, lined with brick to the top. A test of the plant gave the following results :—

Efficiency (output on switchboard to i.h.p.)	76 per cent.
Steam used by engine per kw. hour........................	26·6 lbs.
Total steam per kw. hour, including condenser	27·5 „
Coal per kw. hour (wet)	4·53 „
Kilowatts per lamp	0·43

The working expenses are $48·6 per lamp per annum. W. H. E.

593. *Street Lighting by Electric Lamps.* **F. H. Minshall.** (Elect. World and Engineer, 36. pp. 836–839, Dec. 1, 1900.)—The article deals mainly with the matter of alternate-current arc lighting for streets, and gives the results of the author's experience at Croydon. The following table gives approximately the energy required in a few types of alternate-current arc lamps in common use :—

No.	Type.	Current.	Volts.	App. watts.	Actual watts.	Power factor.
1.	Rectified current, open arc ...	11·8	47	550	520	0·95
2.	Enclosed alternating............	4·7	200	940	650	0·69
3.	Low wattage chokerless type	3·0	200	600	420	0·74
4.	Series alternating enclosed arc	10·0	70	700	530	0·76
5.	Enclosed alternating............	6·7	115	770	510	0·66
6.	„ „	4·4	206	906	540	0·60
7.	Alternating, open arc series...	21·0	37	778	550	0·71

Lighting is required for about 3,710 hours in the year, supposing the lamps to run from dusk to daylight. On this basis the runing cost per year works out as follows, assuming the energy to be supplied at about 1½d. per unit :—

	£	s.	d.
For a 550-watt rectified current open arc	22	10	0
For a 450-watt alternating current enclosed arc	16	10	0
For a 650-watt „ „ „ „	22	0	0

This includes the cost of carbons, and presumably the cost of trimming the lamps ; but does not allow anything for the share of station plant used in generating the necessary energy. Various systems of running alternate-current arcs in series or in parallel are generally dealt with. The article also contains various calculations with a view to determining the most economical conditions of working, the most suitable size of cable for connecting lamps in series, and other points in connection with the operation of lighting circuits.

W. H. S.

TELEGRAPHY AND TELEPHONY.

594. *Wireless Telegraphy.* **W. B. v. Czudnochowski.** (Phys. Zeitschr. 2. pp. 105–107, Nov. 17, 1900.)—For a simple apparatus to demonstrate wireless telegraphy, the writer reverts to the Leyden jar arrangement used by O. Lodge in his original work on electrical resonance. Of various forms described, the best is said to be that in which two jars are used. The inner of the first is connected to a vertical exploring wire which ascends free into the air. The inner of the second is connected to earth. Both outer coatings are insulated from the earth. They are connected :espectively one to each of the secondary terminals of an induction coil by equal wires carefully tuned. R. A.

595. *Cable Duplex with Intermediate Land-Line.* **A. Davidson.** (Electrician, 46. pp. 268–269, Dec. 14, 1900.)—A diagram is given showing the application of Harwood's duplex system to composite circuits composed of submarine cables and land-lines working with siphon-recorders. In the case considered, a cable AB is supposed to be connected through a land-line BC to a second cable CD, so that B and C are the terminal stations of the land-line. Signals from D, received at C in the usual way, are transmitted direct to A. Similarly, signals from A are transmitted by B to D. In order to record what is passing through, and to show the state of the balance, the land-line recorders at B and C are permanently in circuit. If the recorder at B is practically unaffected when B is sending to D, while signals from C to A are of legible size, the same state of things obtains at A, and duplex working is possible. The arrangement can be divided up for sectional working by introducing earths at B and C on the apex to apex lead. The principal source of disturbance is the variation of insulation of the land-line, but the recorders at A and D are so far away from one another, electrically, that the land-line balance must be out very considerably before the incoming signals are affected. The effect of the cable capacity can generally be sufficiently compensated, as regards the land-line balance, by tapping on a large capacity near the end of the land-line artificial lines. The lower the resistance of the land-line, the better the balance. Well insulated batteries at B and C are essential. On a duplex human relay system the arrangement amounts practically to the elimination of one station without introducing any extra contacts or moving parts. The system has been worked successfully over a tropical land-line subject to heavy varying leakage. R. A.

REFERENCE.

596. *Telegraphs and Telephones at the Paris Exhibition.* **J. Gavey.** (Inst. Elect. Engin., Journ. 30. pp. 73–92; Discussion, pp. 93–103, Dec., 1900.)—Amongst others the systems of Rowland, Mercadier, Virag and Pollak, and Poulsen, are described, as also some accessories.